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UNIVERSITY OF ILLINOIS  
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NO. 1**  
1963 - 1964  
NATIONAL SAND AND GRAVEL ASSOCIATION

# Simultaneous Excavation And Rehabilitation Of Sand And Gravel Sites

THE UNIVERSITY OF ILLINOIS

FEB 25 1965

By Anthony M. Bauer  
University of Illinois

**A General Survey and Analysis of Pre-Operational Planning Factors and Procedures**

THIS RESEARCH PROJECT OF THE UNIVERSITY OF ILLINOIS WAS SPONSORED  
BY THE NATIONAL SAND & GRAVEL ASSOCIATION, SILVER SPRING, MARYLAND.







# Simultaneous Excavation and Rehabilitation of Sand and Gravel Sites

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SPONSORED BY THE NATIONAL SAND & GRAVEL ASSOCIATION,  
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# FOREWORD

This is the first report to be published under the Research Program sponsored by the National Sand and Gravel Association at the Department of Urban Planning and Landscape Architecture of the University of Illinois. This program is sponsored by the Association's Committee on Public Relations, and is supervised by a Research Advisory Committee, whose members are named under "Acknowledgments" in the text of this report.

Two members of this Committee, Messrs. Weaver and Thieme, are presidents of companies producing sand and gravel. The two sites used as case study demonstrations of the principles set forth in this report were properties of their companies. The rehabilitation programs illustrated in the case studies, according to Messrs. Weaver and Thieme, would either result in no increase in the cost of operation, or in cases where increased expenses did occur, they would be more than offset by resulting increases in land values.

The Research Advisory Committee concludes, therefore, that the program has thus far illustrated that rehabilitation of sand and gravel lands, if properly preplanned and executed, can be an investment rather than an expense. We are hopeful that subsequent reports developed as part of the Research Program will further illustrate this point.

*Research Advisory Committee*



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**Fig. 1 — Pit Environment**

# Introduction

## Problems

The sand and gravel industry is faced with increasing demands for their product, rising property values, competition for use of land in urban areas, a desire for fair economic return on investment, and increasing opposition by the public against the nature, the results, and therefore the extension of their operations. These factors are related to four conditions.

1. Supply
2. Demand
3. Transportation
4. Land use practices

An active public relations program and participation with local planning authorities in formulating the land use plan can alleviate many problems stemming from these conditions. However, solutions to the problems presented by the fourth condition, which is the object of this and subsequent reports, will be a stepping stone for reaping greater benefits from all four conditions.

A sand and gravel operation is an industrial process that utilizes heavy earth moving and processing equipment and large storage areas for stockpiles and machinery. A drastically altered landscape, noise, and heavy traffic volumes are inherent operational characteristics. These factors produce a land use that is generally incompatible with many urban and some rural land uses. But the persistent creation of derelict lands as a product of their operation and the predominantly disarrayed appearance of the plant area aids, abets, and emphasizes the incompatibility factor, and has nurtured the industry's public image to its current status.

Although the scale of a sand and gravel operation is not as extensive or the results as drastic as some of the operations of other mining industries, the general impact of its plant and operations on the environment is often more severe. Sand and gravel, like many other natural resources, can only be extracted where nature placed the deposit. But, because sand and gravel is a bulky, low-cost material, transportation plays a significant part in determining the economically accessible deposit. The cost — hauling distance (from plant to consumer) relationship has direct bearing on the price of the final product. As a result many operations are concentrated near the primary market area which is the metropolitan center. Within this urban influenced environment, the industry is associated with high density, intensive land use, high land values, and stringent land use regulations. The industry is at a disadvantage in competing with more desirable

land uses such as residential and commercial uses, especially in the light of its past operational practices.

Pressures of the urban environment require more responsible land use policies. Some of the producers have met the challenges of a rehabilitation program and have developed a variety of commendable projects that demonstrate the feasibility and potential for such a program. A number of these projects are illustrated in the National Sand and Gravel Association's "Case Histories" publication. Lakeside residential developments, parks, beaches, sewerage disposal plants, and commercial developments are a few of the existing sand and gravel pit rehabilitation projects.

Although current rehabilitation activity has resulted in noteworthy projects, absence of a pre-determined or planned approach produces remnants of land too narrow, too low, or too steep and bodies of water too small or too shallow on these sites. The scope of the project and the optimum site potentials are not fully realized when development proceeds without defined objectives.

In addition, many of the recorded rehabilitation projects are of questionable value. A planted tree, and a graded or seeded slope does little to alleviate the impact of a scarred landscape or the undesirable image that the industry maintains. Nor is minimal rehabilitation work likely to create an asset to the producer and the community. Also, many of the current rehabilitation projects do not begin until the deposit is depleted. The objectionable characteristics of the operation and the pit must be endured by the public during the life of the excavation process. This factor also plays a part in reducing the land use potential of a particular site.

## Opportunities

The sand and gravel industry is in a unique situation insofar as rehabilitation is concerned. It utilizes heavy earth moving equipment, and often has large volumes of material, unsuitable for processing, available for creating functional land forms. Since it is necessary to move all this material in order to extract the desired natural resources, it becomes a matter of manipulating the equipment in a manner that will achieve the most desirable land areas.

Also, the location of the operations offers unique opportunities in land development. Not only are land values higher with numerous uses vying for a piece of land in the area in which operations exist, but the results of the excavation process may create unique features, such as large bodies of water that might not otherwise be available for development.



**Fig. 2 — A Pit in the Midst of Industrial, Recreational, and Residential Land Uses**

A financial gain is naturally one of the basic objectives of a rehabilitation program. A substantial gain has been realized in many of the existing projects. However, there are such intangible benefits as good will and community acceptance that will open the door for further development of otherwise inaccessible deposits.

## **The Role of the Industry**

A day seldom goes by when we do not come in contact with the products of the sand and gravel industry. Sand and gravel are components in the foundations of our homes and make up a major portion of the roads we travel. These elements are essential in the construction of all forms of structures. There can be little doubt that sand and gravel are vital to the growth of our nation.

But the fact that sand and gravel are essential elements does not and should not give the producers license to carry on an irresponsible land use program. In supplying one national resource the industry significantly affects another (land), and often in a very undesirable manner. However, faced with the dilemma of meeting the expanding needs of increasing populations (expected to double in the next 30 years) with static land area and diminishing natural resources, many producers have begun to realize that land can no longer be exploited as it has been in the past, without significant consequences to their future. Some of these producers have taken the initiative in responsible land use practices, especially where the planning climate has been favorable to the sand and gravel industry. Where there has been a "meeting of minds" between the community and the industry such as in Denver, Indianapolis, and Los Angeles, the sand and gravel producer has adequately demonstrated a responsible attitude to land planning and the relationship of his operations with surrounding

land uses. In these areas he has substantiated his position in the community's land use program to the benefit of all concerned.

The sand and gravel producer's ability to meet rising needs and to cope with existing and anticipated more restrictive land use regulations may often depend upon:

1. Recognition of current problems arising from an expanding urban environment.
2. Responsible use of resources and land.

Mr. Kenneth Schellie of Indianapolis stated, "It is good to use the land but it is bad to use it up."

The public does not sense the value and vital role sand and gravel fills in their daily lives. They are aware of the noise, dust, appearance, and hazards that exist during the operations, and the character of the land when operations cease. Not only must the industry show the need for its product but it must illustrate responsible land programs that will reduce the objectionable qualities of the extractive process, and create a land asset rather than a land liability. In view of these and other problems and opportunities of the industry, research can be an effective tool to analyze problems and develop solutions which will facilitate continued growth, development, and public acceptance of the industry.

## **Research Program**

### **Objectives**

The hypothesis upon which this research program is based is that sand and gravel operations can be effectively planned, (1) for the development of an optimum, practical, and aesthetic use, and (2) for the reduction of inherent noise and visual conflicts associated with normal operations, before the operation is initiated; and that the excavation and develop-

ment process can progress simultaneously without reducing the efficiency of either operation. This can be accomplished through the application of appropriate basic landscape architectural principles of conservation, restoration, and creation of environmental values by means of survey and analysis, site design, grading, planting, and controlled development of the inherent resources of the site and operation.

Therefore the objectives of this first project have been to identify significant site and operational factors of the total industry, to review opportunities for sand and gravel site development, and to determine appropriate guide lines for planning procedures which will facilitate optimum development for the benefit of the sand and gravel industry in accord with public interest.

### Research Methods

The execution of this study was completed by the following procedures:

1. Survey. This part of the study required the greatest attention simply because little information in terms of the objectives of this report was available. So a variety of surveys were conducted to get acquainted with, and to obtain an insight of, the industry.

The collection and recording of basic data by review of pertinent literature was the first method. This was followed up by a field reconnaissance of thirty-five midwestern sites which was later increased to field checks of thirty sites in Maryland, Wisconsin, Nebraska and Colorado. The third survey method was the formulation of a questionnaire submitted to a group of producers representing a cross-section of the sand and gravel industry in the U.S. Picture-taking aerial reconnaissance was the last type of survey conducted. Two flights, one to Southern Wisconsin and one to Western Ohio, were completed.

2. Analysis. This procedure involved the organization and evaluation of survey information to determine potential problems and opportunities in relation to possible approaches to planning and design.
3. Deduction. On the basis of survey and analysis results, conclusions and recommendations for planning procedures were formulated.
4. Application. A case study was developed to test the conclusions and demonstrate the recommendations. An additional case study, not directly related to this project, but containing pertinent elements, is included to demonstrate various recommendations.

This report is divided into two sections. Section I, *Survey*, is composed of four chapters and is devoted to a review of the general characteristics of the sand and gravel industry. Section II, *Planning Procedures*, includes an analysis of the survey information to determine the factors that will significantly influence the planning process; and recommended procedures for the development of the ultimate use of sand and gravel sites.

### Summary of Findings

The sand and gravel industry is in a unique position to contribute to the growth and development of the nation. Not only does it process a basic resource essential to the construction industry, but it contains resources and conditions within the sphere of its activities that provide opportunities to mold the excavated land into real estate that is an asset to both the producer and the community. Three typical characteristics of the industry that contribute most to the development potentials of a sand and gravel site are:

1. Material unsuitable for processing
2. Heavy earth moving equipment
3. Location — in relation to the urban environment

Current rehabilitation practices are primarily directed toward improving the conditions created by the excavation

process. A number of these sites contain successful land use projects. But in many of these sites the fullest potential is not achieved, as indicated by the various unusable land and water areas. In addition, minimum effort is being directed toward improving the appearance and reducing the conflict of the plant and excavation area during the life of the operation. As a result the established undesirable image of the industry is preserved.

There are several factors that limit or deter rehabilitation activity. These factors must be realized before a plan for development is formulated in order to cope satisfactorily with the obstacles they present. The most significant of these are:

1. Low land values.
2. Lack of suitable grading and earth moving equipment.
3. Extensive and dramatic pit conditions.
4. Ownership.
5. Separation of rehabilitation and excavation operations.

Development of the ultimate land use potential of a sand and gravel site requires an organized planning program to correlate site, operational, and environmental factors with a concurrent excavation and development process. The proposals and subsequent development procedures are based on the character and structure of the site, the capabilities of the equipment, and the influences of the environment, utilizing the assets and reducing the conflicts of the total activity. Information about these influencing factors is essential in identifying the most effective approaches to land development. The detail of this information will determine the success of the plans.

Following is a brief summation of a planned approach to the development of a sand and gravel site:

1. Initiate the planning program upon purchase of sand and gravel property.
2. Review information pertinent to planning decisions about the:
  - a. Deposit.
  - b. Operation and equipment.
  - c. Environment.
3. Screen any anticipated objectionable characteristics.
4. On the basis of the above information determine appropriate land use and land patterns.
5. Integrate the development of these land patterns with the excavation process.
6. Improve the general appearance of the plant area.
7. Progressively develop the proposed land use.

In addition to creating functional land areas, a development program should improve the physical appearance of the plant, thereby making the operation more compatible with the surrounding land use. These two objectives can be accomplished because the capacity for land development and improvement of physical conditions is contained within the site, the operations, and the surrounding environment. Planned development exploits this capacity.

### Limitations of this Study

This initial project has been primarily concerned with identifying the broad range of problems, characteristics, and potentials in the sand and gravel industry. Many subjects have only been touched upon; for example, to what extent can certain types of equipment become involved in development? What are its hauling or grading capacities? These are only two of many remaining unanswered questions.

Several limitations, insofar as the scope of this project is concerned, should be noted. First, much of the information is identified with the sand and gravel industry in the Midwest. Time and transportation has required the author to concentrate field reviews and aerial reconnaissance on this area. Literature and surveys concerning the industry in this area were also more readily available.

Future projects will involve more detailed study and will hopefully cover all sections of the country.



# SECTION I

## Chapter 1

# Deposit

# Survey

An understanding of the influencing features of sand and gravel deposits and operations is necessary in determining knowledgeable approaches to the ultimate development of a site. Basic data about the deposit and soil conditions, equipment, operational procedures, and the environment are essential. The validity of the planning proposals depends upon the accuracy and completeness of this basic information.

The following section is devoted to a survey of the elements and conditions of the sand and gravel industry. It is the intent to acquaint the reader with the general character of the industry, and to establish a foundation of information from which general planning guide lines can be determined. No solutions to "individual" problems will be drawn except from derived principles applied to the "case study" and from future projects concerned with specific problems.

Sand and gravel deposits are located in a wide range of land forms. The glacial, glacial fluvial, and fluvial created landscape of hills, plains, terraces, and valleys are all major sources of this vital material. Water was the major element in forming the deposits, and its activity is clearly recorded in these land forms.

Water transported unconsolidated material downstream from the glacier or parent rock. Along its downward journey it sorted the debris, dropping the heavy material near its source while carrying the finer granules downstream until only fine sand and silt remain in suspension. The variable speed of the water created the variable layers of material. At certain times torrents of water carried heavy material further downstream. At other times layers of fine sediment were deposited over the coarse aggregates by calm waters, again to be picked up by a more rapid flow. Occasionally a swift stream flowed into a still body of water depositing all but the fine sand and silt at the entrance point; or the water spread sheet-like over the landscape depositing broad layers of consolidated material; or the water was channeled, weaving back and forth within the confines of surrounding topography, increasing and decreasing velocity, picking up and dropping material, and cutting and building the land forms.

Thus, water, a sorting agent, a transporting agent, a cleansing agent, and a sculpturing agent, formed the flood plains, outwash plains, alluvial fans, valley trains, stream terraces, eskers, kames, and deltas from which the commercial supply of sand and gravel is excavated.

## Distribution

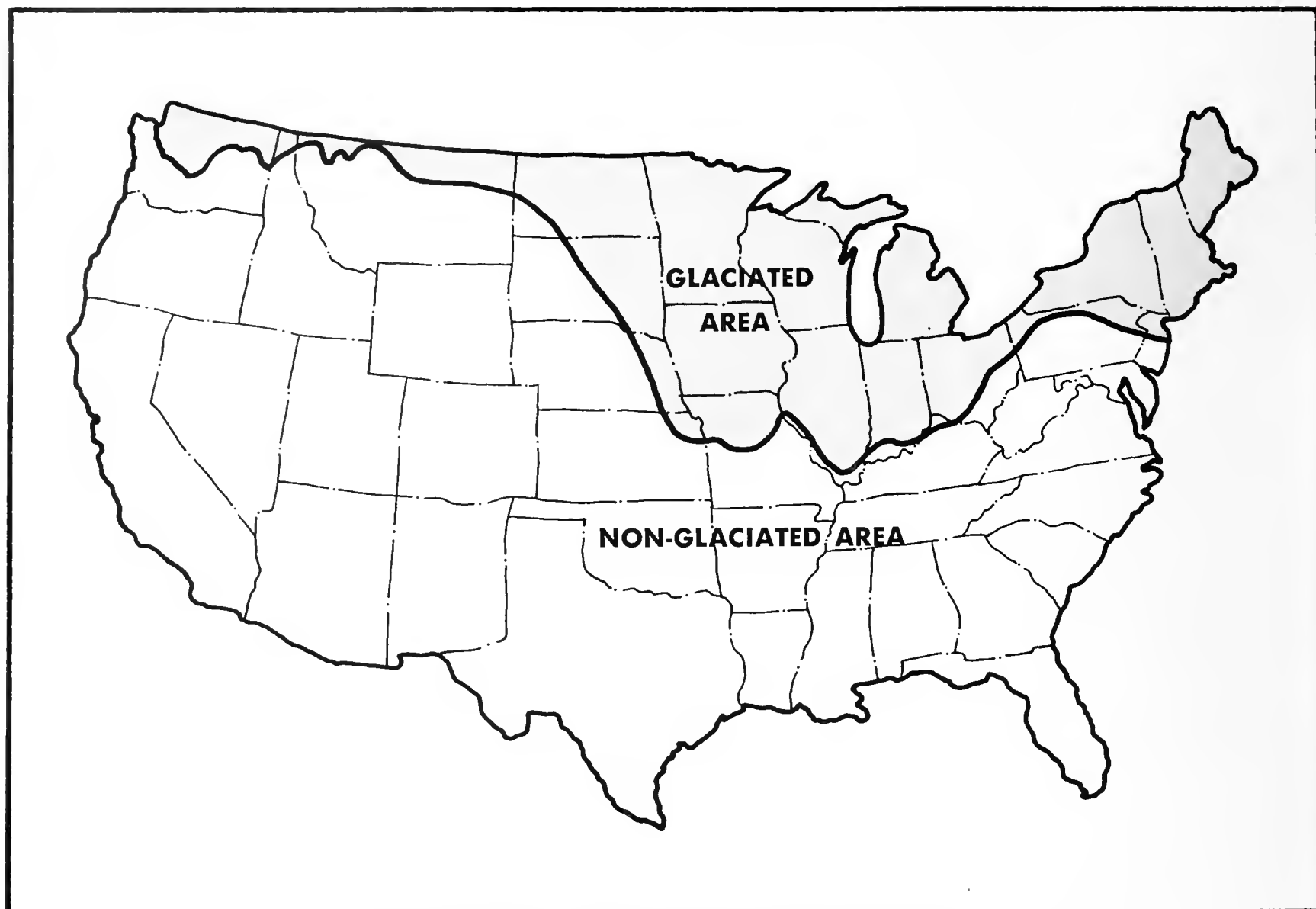
Although vast undetermined amounts of sand and gravel exist in the United States, unequal distribution of these deposits leaves many sections of the country with limited or no resources. It is important to remember that when one speaks of the availability of sand and gravel deposits in various geographical areas, this does not mean that the deposits are available in an economic sense. Because transportation is such an essential factor in the cost of sand and gravel, deposits not located close to the market area are of little commercial value. As stated later, for example, deposits located in mountainous areas in the West, while they may be abundant, are not economically available to the market areas in metropolitan centers.

The two general types of deposits, glacial and fluvial, have identifiable boundaries with shortages peculiar to each area. (Fig. 3). However, as a general statement, it can be said that glaciated areas contain a greater reserve of sand and gravel than non-glaciated areas. A noted exception is California where enormous reserves of fluvial deposits exist.

Fluvial deposits are limited primarily to the lineal corridors of drainage ways. Few deposits exist outside of this lineal pattern. But in glaciated areas, while deposits occur in the lineal pattern of a glacial stream, numerous types of deposits such as eskers and outwash plains are available. These deposits are likely to be distributed more evenly throughout a geographic region and be much more extensive areally and in depth than the fluvial deposits.

In describing the distribution of sand and gravel deposits in the United States, only the general characteristics and availability within regions will be identified.

Within the glaciated area, extending from the northeastern Rockies east and southward toward southern Illinois, Indiana, and Ohio, and up into the northern section of New England,



**Fig. 3 — Regions of Glacial and Fluvial Deposits**

deposits are abundant with only local scarcity. According to the 1962 production figures in *Minerals Yearbook*, about half of the processed sand and gravel in the United States is produced in this northern region. Reserves are plentiful at the present time, but localized scarcity of quality sand and gravel exists.

Along the eastern coast south of New York, deposits originate primarily from fluvial action. Deposit reserves are adequate but become scarce into and south of Virginia. North of Virginia the bulk of the commercial sand and gravel is excavated from moraine and stream terraces.

In the southern United States east of the Mississippi River, the supply of quality sand and gravel is extremely scarce. Sources are limited to stream deposits with some alluvial fan and delta deposits available. These deposits contain a considerable amount of unmineable material such as large quantities of fine material.

In Louisiana and Texas, deposits of fine grained material are adequate. They exist in the form of flood plains, deltas and terraces. Throughout the Rocky Mountain states deposits are fluvial in the forms of flood plains and alluvial fans. Reserves in the plains along the base of the mountain ranges are limited but considerable supplies of coarse aggregates exist in remote mountains for future development. Access and transportation costs currently prohibit extraction of these far removed deposits. In Utah, a tremendous source of sand and gravel exists in the terraces along the old shorelines of Lake Bonneville. It is the major source of sand and gravel in that area.

California contains a vast sand and gravel reservoir. The material exists in stream channels, flood plains, terraces, and alluvial deposits. In 1962 one-sixth of all commercial sand and gravel produced in the United States was processed in California. Reserves are considered very adequate with local shortages.

## Exploration

Sand and gravel deposits, by their nature, lack a uniformity which limits understanding of their structure and commercial value. Deposit information concerning location, pattern, size, depth, and sub-surface characteristics must be revealed to the sand and gravel producer before he can begin excavation. This information is attained by various forms of exploration and an experienced understanding of local formations.

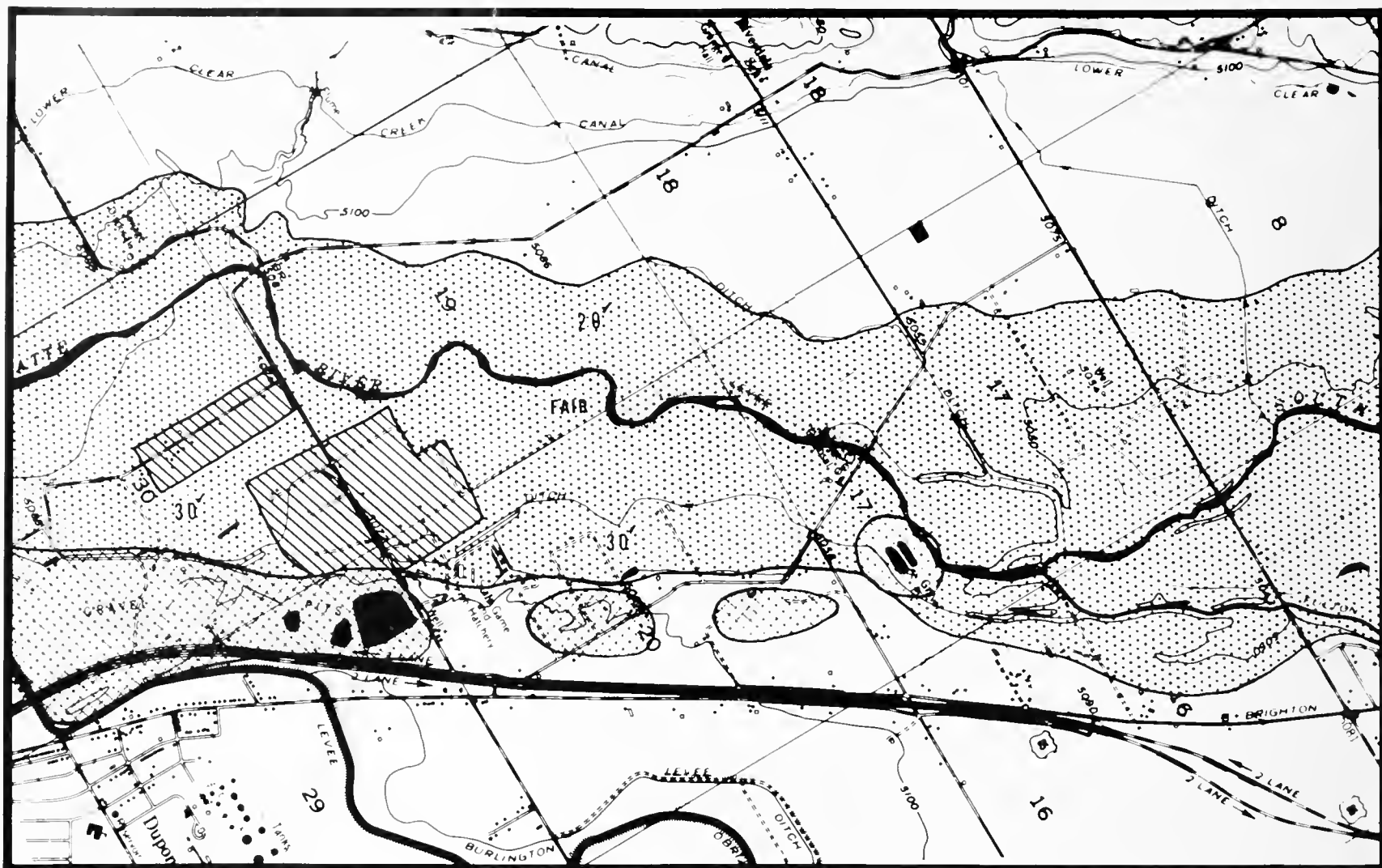
The process of exploration involves two steps. First is a preliminary investigation to identify the general patterns and locations of the deposits. It may also provide the producer with a broad picture of the deposit structure. The second step is detailed and will provide information about the sub-surface patterns and characteristics from which the producer will determine the value of the deposit and the type of operations required to extract and process the material. Many sources and techniques are available for gathering information for both of these steps.

Aerial photographic and topographic maps, and U. S. Coast and Geological Survey maps are useful tools for defining areas that contain potentially valuable sand and gravel deposits (Figs. 4, 5, and 6). This information is available at local, regional, and state planning offices, agricultural extension offices, U. S. Geological Survey offices, local and state conservation districts, and numerous universities. Many states and local areas, especially in heavily populated regions, have complete and recent aerial photographic and topographic coverage. The aerial photographs are available in scales of 1" = 1000' and 1" = 400' while the topographic maps are commonly at a scale of 1" = 200', with five foot contour intervals. The U. S. Coast and Geological Survey maps are available in different scales with 1:2400 (1" = 2000') most frequently used. The contour interval on these maps is either five or ten feet.

This is a topographic map of a coastal area. The map features several contour lines indicating elevation. Key elevation markers include 951.0, 952.0, 953.0, 954.0, 958.0, 959.0, 961.0, 963.0, 964.0, 975, 975.0, 981.0, 982.0, 984.0, 987.0, 989.0, 992.0, 997.0, and 1001.0. A road, represented by a dashed line, runs horizontally across the middle of the map. A road with cross-ticks runs diagonally from the bottom left towards the center. A small area labeled 'WL' (water) is located near the top left. A small rectangular feature, possibly a building or structure, is located near the center left. The map also shows a coastline with a small inlet or bay on the right side. The overall terrain appears to be relatively flat with some minor elevation changes.

A detailed topographic map showing the Lincoln Homestead Memorial Park area. The map features contour lines indicating elevation, with labels such as 600, 610, 620, 630, 640, 650, 660, 670, and 680. Key locations include Gravel Pit, Lincoln Trail Bridge, Muirhead Cemetery, Brown Cam, Hudson Cam, and Gravel Pits. A grid system is overlaid on the map, with section numbers 29, 28, 26, 33, 34, and 35 visible. The map also shows various roads, trails, and other geographical features like hills and valleys.





**Fig. 7 — Location, Depth, and General Quality of Gravel. (Drainage Course Plan for the Denver Region; Part I, Sand and Gravel Resources)**

Interpretation of the natural, cultural, and topographical features illustrated on these maps will reveal the sand and gravel bearing land forms described later in this chapter. Also, by plotting existing gravel pits, their frequency and location patterns may illustrate a greater or lesser potential in a particular area. As a result a specific area may be outlined for more detailed exploration.

Well records, stream beds, and engineering boring records are also useful sources of information for pin-pointing valuable deposits as well as providing detailed information. When this information is coordinated with the above data, a rather thorough picture of deposit patterns and locations can be achieved. However, a review of this information by a consulting geologist who is skilled in identifying land forms and sub-surface conditions, can result in the most accurate and detailed interpretation of existing conditions and save many hours of detailed exploration.

In addition to the above sources of information, some sections of the country have survey maps illustrating glacial deposits and sand and gravel resource deposits in varying forms of accuracy and detail (Figs. 7 and 8). These maps will eliminate much of the general survey work but not the detailed investigation. Most of them have been compiled from above mentioned sources by competent geologists.

Once it has been determined that an area or site contains a potential sand and gravel deposit, detailed exploration on the site will begin. This exploration is accomplished by a variety of methods. The most common are resistivity methods, drilling, and digging.

The resistivity method is used primarily to outline the deposit. It functions on the basis of an electrical current and resistance of various materials to this current. The resistance factor of the materials is known. For example sand and gravel have greater resistivities than clay soils.

Tests are accomplished by driving two electrodes into the ground. An electric current flows through the ground between

these electrodes. Any change in resistivity will indicate some change in material at a given depth. This test has also been used, with limited results, to define depths of overburden, unsuitable deposits, and sand and gravel characteristics.

Drilling is one of the most common methods of determining deposit characteristics, especially in deep deposits. Various types of drills are used depending on the size of material in the deposit. They include, among others, jet drills and power augers. The number of test holes dug varies from one per ten acres to one every two acres. A factor that influences a larger number of test holes is encountered or suspected changes in the deposit structure.

The other type of test, digging by back hoe, shovel, etc., provides the most accurate account of the pit material because it exposes the deposit along the excavated banks. However, this method contains significant limitations due to the fact that it requires considerable time to dig a suitable test hole, and because these holes generally do not exceed depths of twenty feet.

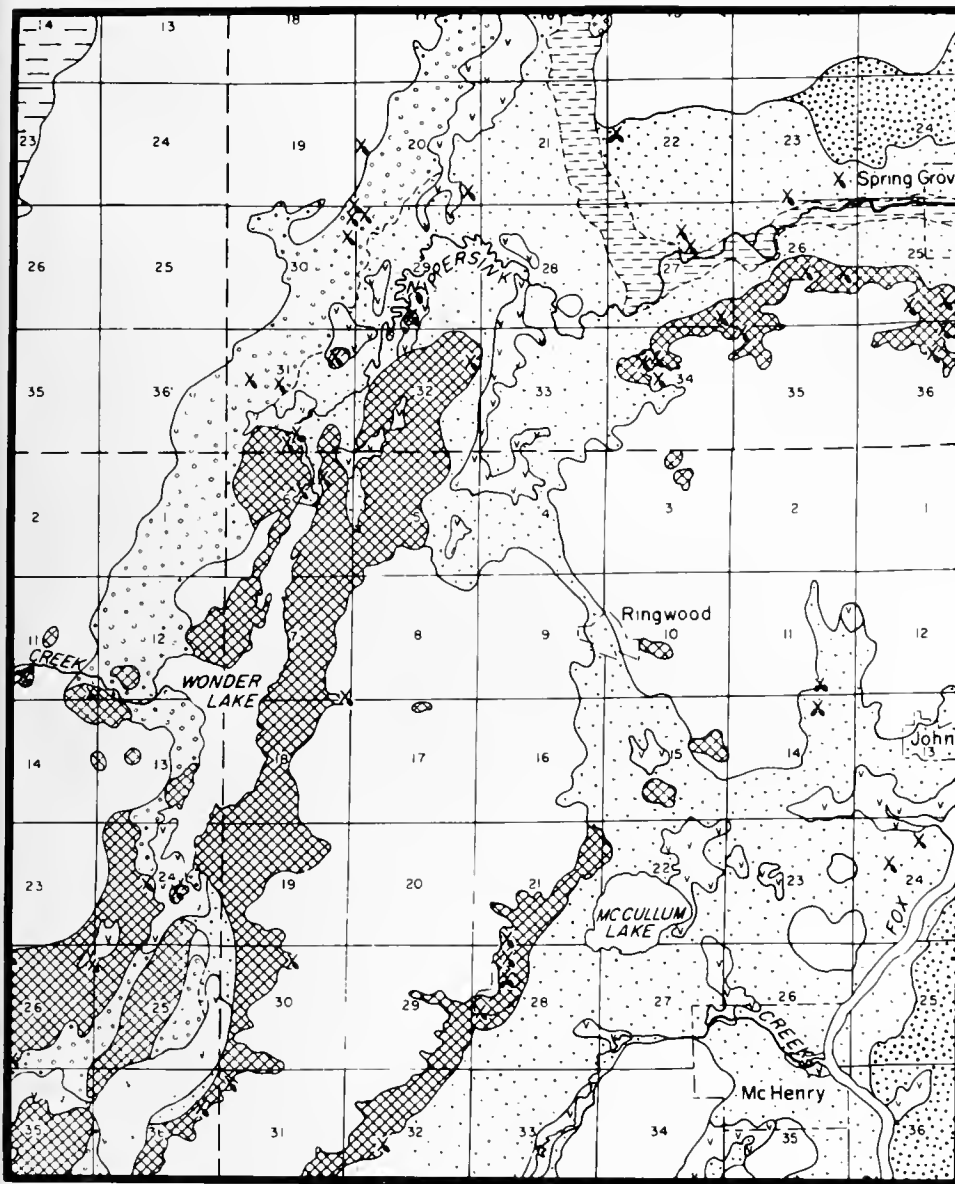
Other methods of identifying deposit characteristics include review of nearby well records, gravel pits, and engineering boring records.

The objectives of these detailed tests are to map:

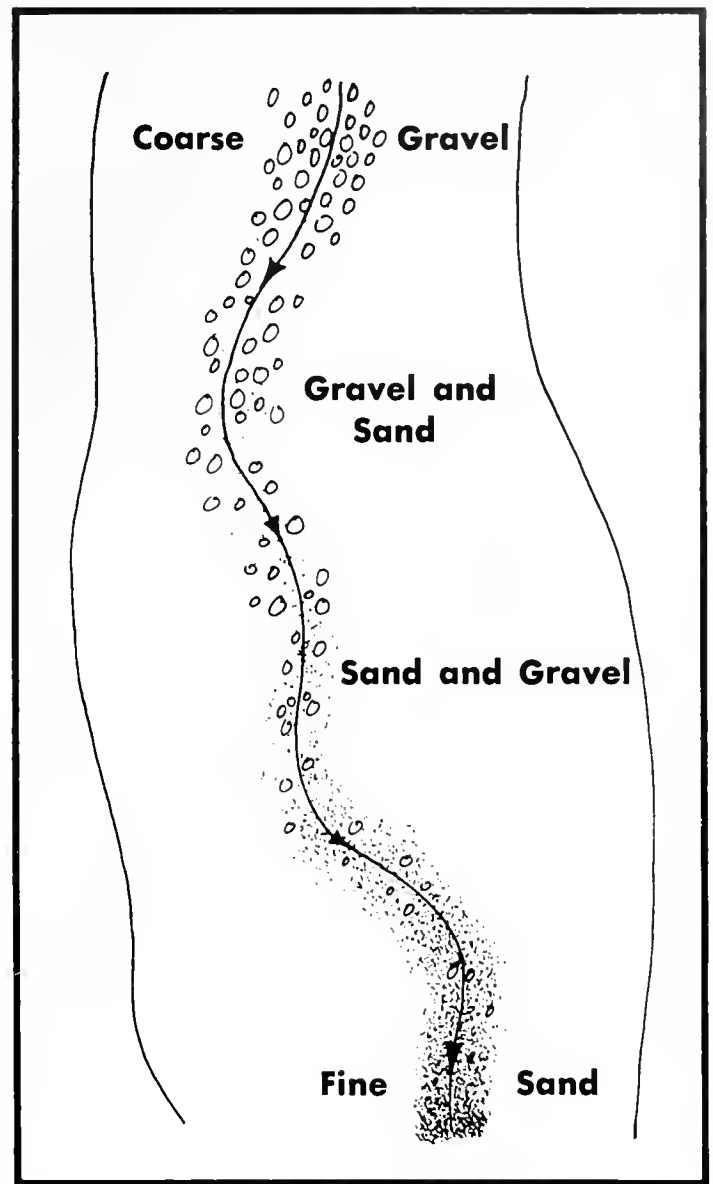
1. Deposit outline.
2. Depths of overburden, sand and gravel.
3. Composition of sand and gravel.
4. Presence of unmineable material: location, depth, and area.
5. Water level.

When this information is mapped, the producer proceeds with an operation that is best suited to the individual site and that will most satisfactorily produce the material required by the local market. After initiating the excavation process several more tests may be conducted, especially if some significant and unexpected change is encountered.

In addition to the above methods of exploration, a basic



**Fig. 8 — Sand and Gravel Bearing Lands (Sand and Gravel Resources; McHenry County, Illinois)**



**Fig. 9 — Material Gradation by Water Movement**

understanding of the sand and gravel bearing land forms assists the producer in his exploration procedure. Many of the producers have attained this understanding through practical experience. As a result, areas barren of the natural resource do not receive the preliminary attention that would otherwise be devoted to them. Also, detailed explorations of existing deposits are conducted in a more thorough manner.

Following is a review of the most significant sand and gravel land formations.

## General Deposit Characteristics

Insofar as the sand and gravel producer is concerned, every deposit is an individual, unduplicated formation. It contains characteristics that are unique to the type of land formation and to the specific site. However, there are four general characteristics that are found in most sand and gravel deposits.

1. Deposits closest to the source of their materials (parent rock or glaciers) contain the coarsest materials. Streams of water dropped the heavy material first while the lighter grains were carried farther downstream (Fig. 9). The gradation of material size, and the distance between the coarse and fine deposits depended on water volume and velocity. Deposits farthest upstream sometimes contain as little as 10% sand while downstream deposits are composed of up to 90% sand.
2. Besides the general gradation of material, there is usually considerable compositional variation within each deposit. Within short distances, horizontally and vertically, the amount of sand may vary from 30% of the deposit to 90% of the deposit. Here again water played a significant role. Changes in the volume and velocity of the stream formed variable

compositional patterns by carrying the coarse material greater or lesser distances.

3. Almost every deposit contains some unmineable material. These materials include clay, silt, glacial till, and stone formations. They exist in the form of veins, pockets, mounds, or lenses of different sizes, and at various locations within the deposit. Also particles of undesirable material such as wood, soft stone, large rock, or aggregates that contain chemicals deleterious to construction activity, may be mixed within the sand and gravel.
4. Most deposits are mantled by overburden. The depth of this cover ranges from zero inches to forty feet with local variations as much as thirty feet. The overburden contains from zero inches to four feet of topsoil of varying agricultural value.

## Land Forms

Sand and gravel bearing land forms were created by ice and water. The land forms are identified with either a glaciated or non-glaciated area and are referred to as glacial or fluvial deposits. Deposits situated beyond the glacier, but a direct result of the ice sheet are termed glacial-fluvial. In all areas, water was the primary deposit forming agent. Where there was no water movement there are no commercial sand and gravel deposits.

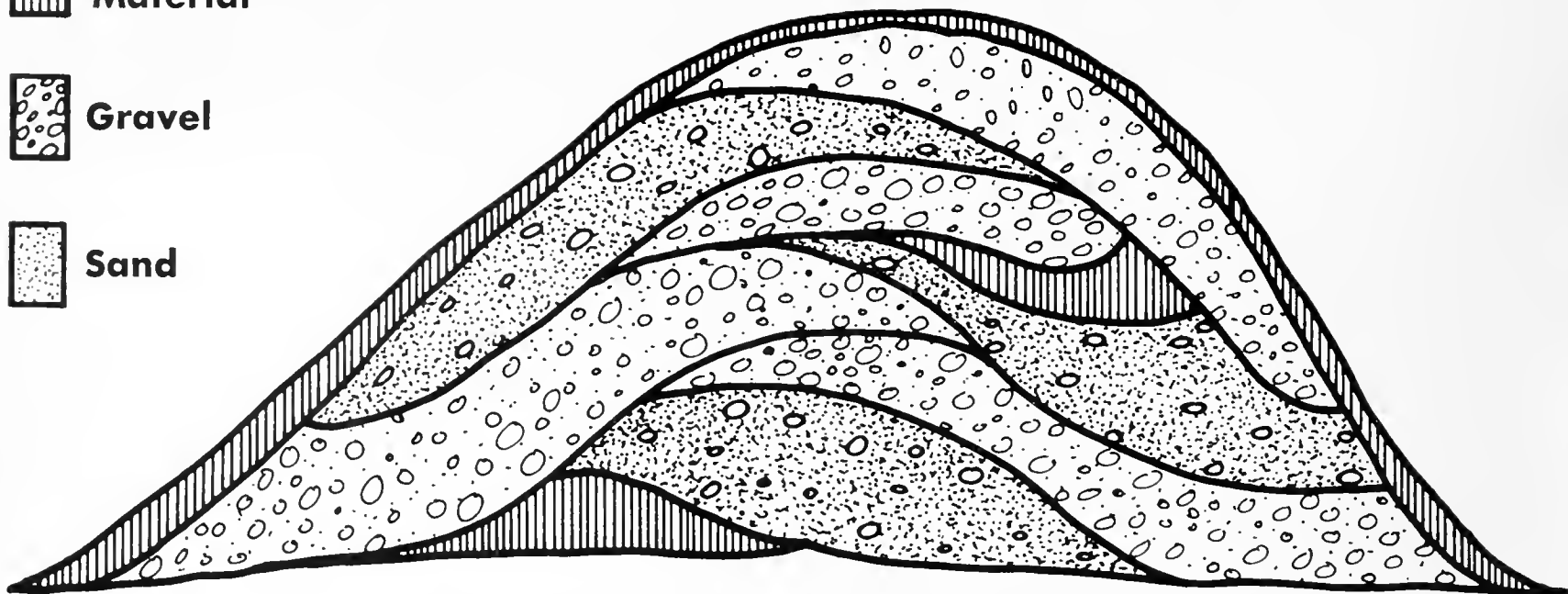
### Glacial Sand and Gravel Bearing Land Forms

Kames, eskers, outwash plains, valley-trains and deltas are the major source of commercial sand and gravel in the glacial landscape. The kames and eskers are ice-contact formations, formed by melt waters flowing in and on the glacier. These land

 **Unmineable Material**

 **Gravel**

 **Sand**



**Fig. 10 — Cross-section of a Kame and Esker Deposit**

forms are located within morainic country such as in Minnesota, southern Wisconsin, and northern New York. Outwash plains and valley-trains are outwash formations resulting from glacial melt waters emerging from the ice sheet. These formations are familiar in central Illinois, southern Indiana, and southern Ohio.

#### **Kames**

Kames are irregular, somewhat conically shaped, steep-sided hills associated with hilly terminal-moraine belts. The size of these hills are variable and seldom exceed 200 feet in height. They contain material that is large, poorly sorted, and irregularly bedded. Often, unusable glacial till is present., (Fig. 10).

Although kames contain quality sand and gravel, the unconsolidated characteristics of the deposit limit its commercial value. In some areas these land forms are exploited, but when other types of deposits are available the kame is a secondary source of sand and gravel.

Within the morainic landscape these deposits are numerous. They exist in areas of several miles long and several miles wide. Often the hilly deposits are tree covered.

Three factors worth noting about a kame sand and gravel deposit are:

1. The deposit exists in hill formations.
2. The material is poorly sorted.
3. The deposit is limited in area.

#### **Eskers**

A narrow, winding, and steep-sided ridge that is located in plain-like ground moraines is known as an esker. These forms are thirty to several hundred feet wide and seldom rise more than 100 feet above surrounding terrain. The crest of an esker is smooth to undulating but occasionally takes on the appearance of a series of small hills. The land forms may extend disjointedly for about 100 miles (Fig. 11).

Eskers, like kames, are irregularly bedded deposits that contain significant quantities of clay, silt, and large rock. However the sand and gravel are of a composition and quality that encourages development of this land form. When formations are large they are good sources of commercial sand and gravel.

The prominent characteristics of esker deposits are:

1. Elongated, serpentine-like form.
2. The hill formation which rises above surrounding terrain of low relief.
3. The irregular deposit structure.

#### **Outwash Plains**

Many streams over-loaded with rock debris emerged from the glacial front. Some of these streams were channeled, forming the valley train deposits to be discussed. Unrestricted streams burdened with debris, built alluvial fans near the ice sheet that eventually coalesced into plains of low relief called outwash plains. These land forms are areally extensive and slope away from the ice front (Fig. 12).

Materials within these deposits are well sorted and horizontally stratified (sheet like) (Fig. 13). Deposits of unmineable materials are often present and exist in stratified layers under, between, and over the layers of sand and gravel. Deposit depths vary from five to one hundred feet. Generally deposits situated at the terminus of the outwash formation are the shallowest. They also contain a greater percentage of sand.

In the outwash plain deposits, ground water is relatively close to the surface. It may be from two to twenty feet below the surrounding terrain. The fact that this land form is relatively flat has some bearing on this feature.

The outwash plain is one of the most important sources of sand and gravel in the central Midwest. Although high percentages of sand are common in this land form, the graded characteristics of the material and the extensive size of the deposits, make it a very desirable type of land form to exploit.

In summary:

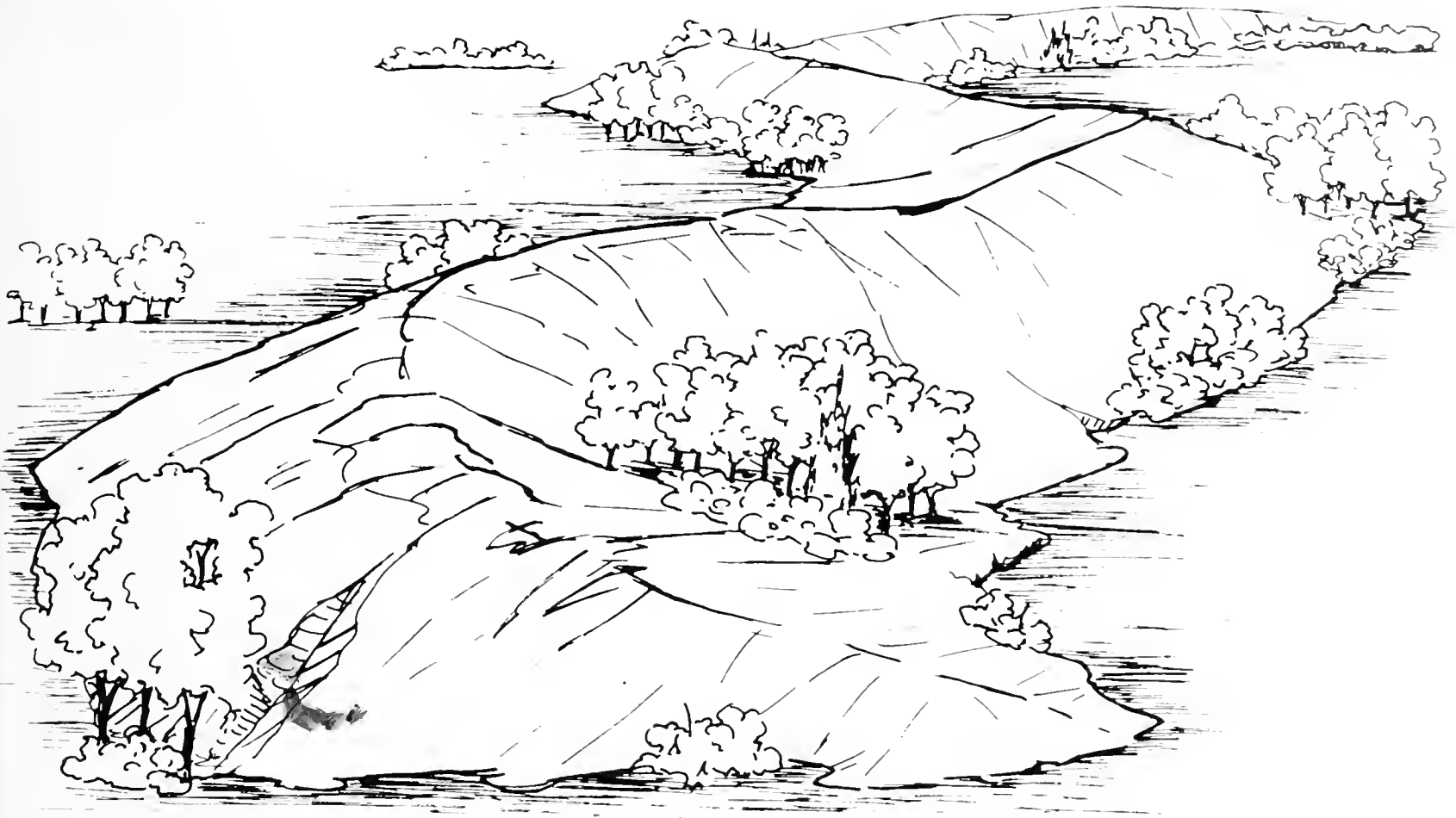
1. Deposits are extensive.
2. The formations are relatively flat.
3. Material is well graded.
4. Ground water is very near the surface.

#### **Valley Trains**

Valley trains are elongated terraces of horizontally stratified layers of material. They contain continuous deposits of commercial sand and gravel. These deposits extend along rivers and their major tributaries and are limited in area only by the valley walls and by the presence of unmineable materials deposited by the glacial streams. The depth is variable but may be to more than 100 feet.

These deposits were laid down by glacial melt waters emerging from the ice sheet into a valley. The terraces were formed by debris laden streams that weaved back and forth across the valley floor, depositing material and eroding what had previously been deposited (Fig. 14).

The material in these deposits are well sorted. However, due to severe changes of the stream velocity, the horizontal layers often contain material that varies considerably in com-



**Fig. 11 – An Esker Formation**

position from the adjacent layers. Unmineable deposits are also stratified but occasionally protrude through several layers of sand and gravel.

The valley train formations contain significant sand and gravel deposits of quality material. The deposits are extensive areally as well as in depth. The most noteworthy features of this type of deposit are:

1. They are extensive.
2. They contain well sorted material.
3. They are either situated on a miniature-like plain on top of a terrace, or at lower elevations in the bank of a terrace.

### Deltas

When rivers laden with sediment flow into a still body of water such as a lake or ocean, the change in velocity will cause a major portion of the sediment to suddenly drop, thus forming successive layers of material in fan shaped patterns called deltas. The formations are associated with glaciated and non-glaciated areas.

As the sediment is carried into the still water the coarse material is dropped first, forming steep inclined layers of aggregates. These layers are called foreset (Fig. 15). The fine sediment such as clay and silt is carried further into the still water and settles to the bottom forming a layer of material termed bottomset, which is covered by the foreset layers as the delta expands. As the delta enlarges, the incline of the foreset strata is reduced and will eventually emerge above water line. Then the topset or final layer of material is deposited over previous depositions. The gradient of this layer is slight and as streams of water loaded with debris flow over it, they divide into smaller streams aggrading and sculpturing the newly formed surface by deposition and erosion.

The depth of this type of deposit often exceeds 100 feet. Part or even a major portion may be under water. The material is well sorted but distinct inclined layers of material loaded with unmineable debris is common.

In New York State, glacial associated deltas are the most significant source of sand and gravel. The deposits are extensive areally but especially in depth.

Factors concerning delta deposits that warrant consideration are:

1. The material is well sorted.
2. Distinct layers of unmineable material are common.
3. A good portion of the deposit is likely to be below ground water.

### Fluvial Sand and Gravel Bearing Land Forms

Fluvial sand and gravel deposits are formed by water action other than glacial melt waters. Four major sand and gravel bearing land forms are attributed to fluvial action; (1) flood plains, (2) alluvial fans, (3) alluvial terraces, and (4) deltas. These deposits are situated beyond the influence of glaciation in eastern, southern, and western sections of the United States. Generally the deposits are restricted to lineal patterns along the major drainage courses; however, the flood plains and alluvial terraces can be quite extensive areally.

### Flood Plains

The flood plain landscape is one of low relief, bordered by steep, gentle, or sometimes almost undistinguishable valley walls. These walls may be separated by distances of several miles with extensive sand and gravel deposits existing between them.

Material within this formation is well sorted and stratified. It contains a high percentage of sand. Pockets or islands of silt and clay deposited by calm waters or of coarse aggregate graded and cleansed of fine sediment by swift waters, are common variations in the deposit. They occur at different elevations and locations in the flood plain corridor.

Ground water is near the surface in this type of deposit. It may occur anywhere from two to twenty feet below grade.

The most important features of a flood plain deposit are:

1. They are of low relief.
2. They contain well sorted material with a high percentage of sand.
3. Ground water is relatively near the surface.
4. They are often enframed by valley walls.



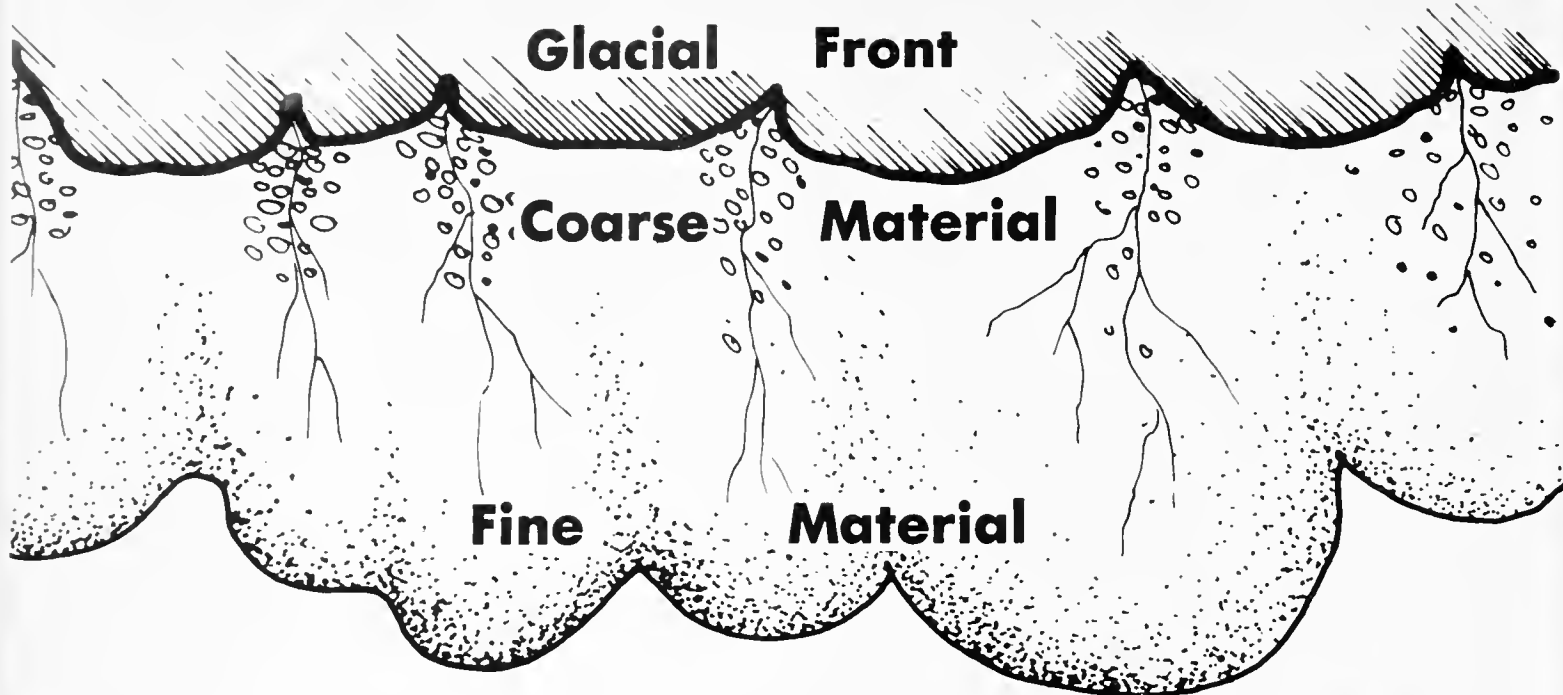
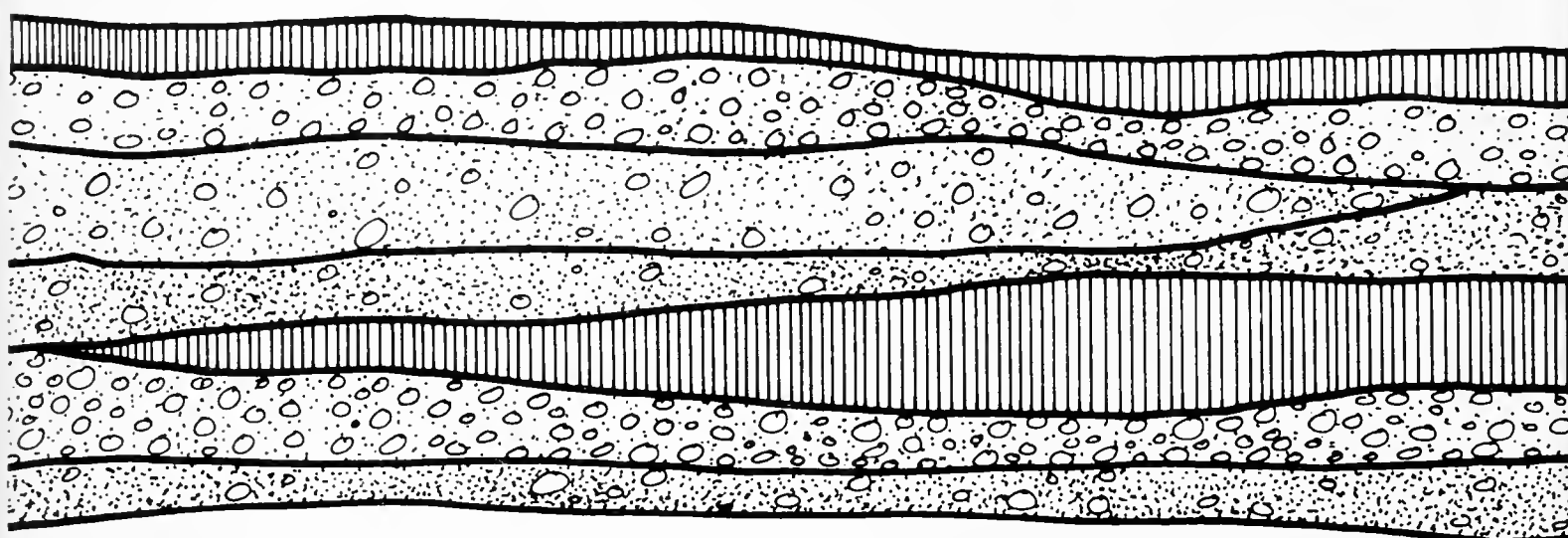


Fig. 12 —  
Plan of an  
Outwash Plain De



**Unmineable  
Material**



**Gravel**



**Sand**

Fig. 13 —  
Cross-section of a  
Outwash Plain De

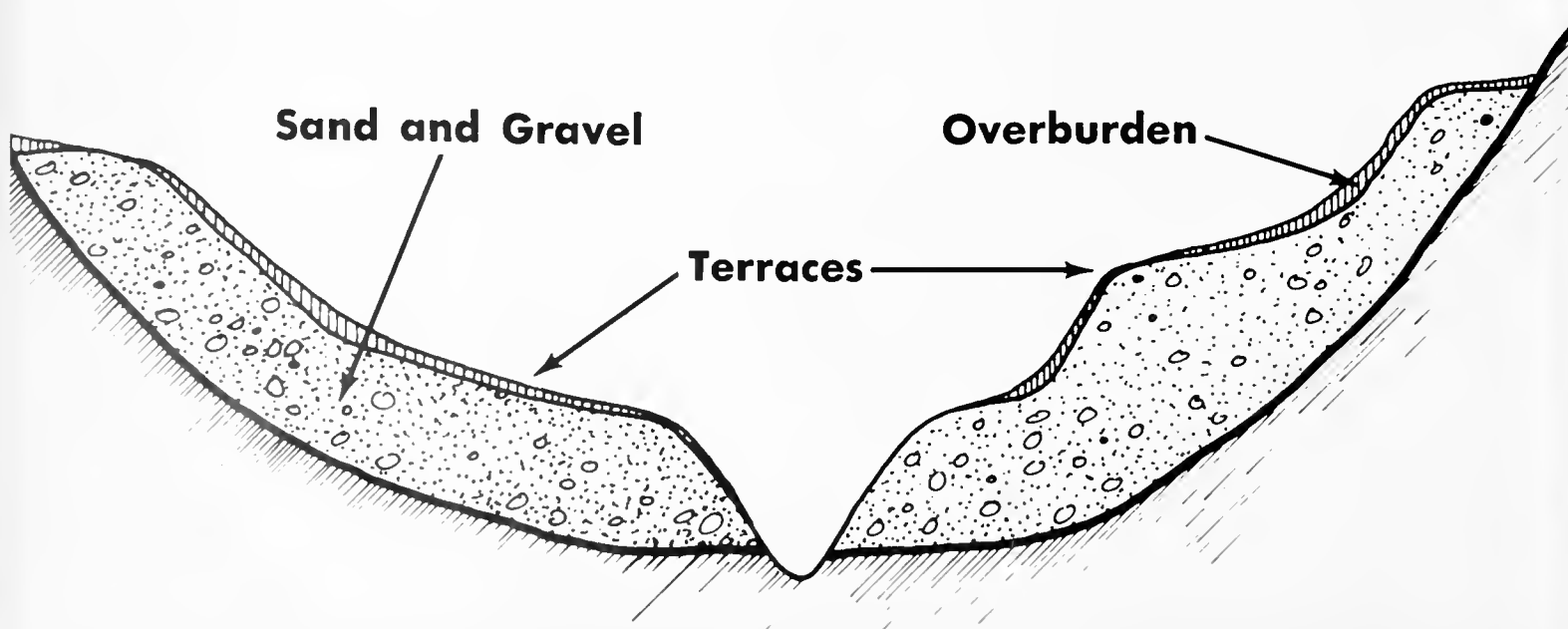
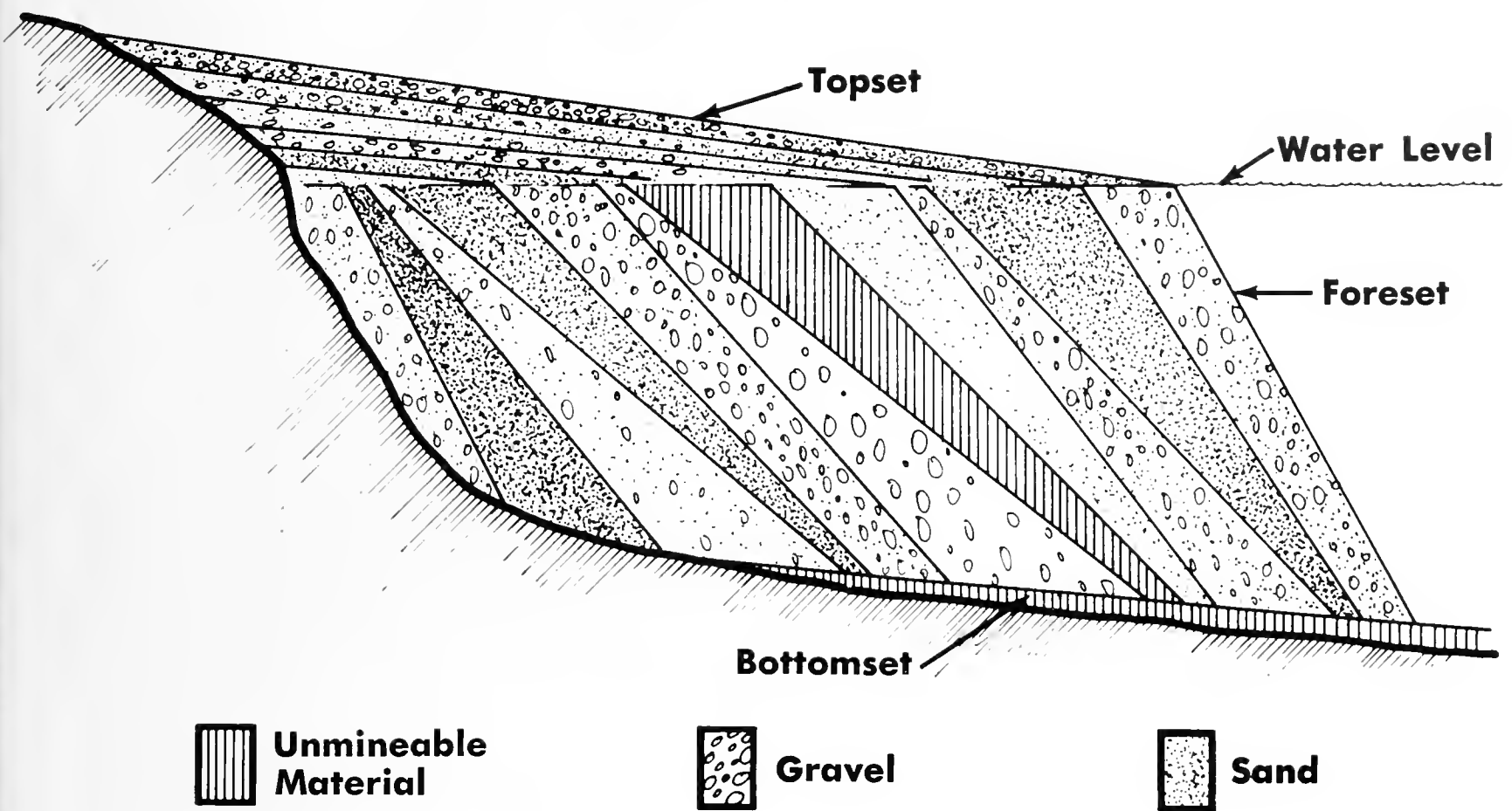


Fig. 14 —  
Cross-section of a  
Valley Train Depo



**Fig. 15 – Longitudinal section of a Lake Delta**

#### Alluvial Fans

Alluvial fans are formed by torrents of water rushing down steep slopes into valleys or plains. As the channeled stream reaches the gentler gradient of a valley, it loses its velocity and disperses, fan-shaped, away from the channel and steep slopes, releasing heavy sediment at the entrance of the valley and spreading the fine material toward the terminus of the fan (Fig. 16).

The material is sorted and deposited more or less with the coarse aggregate near the entrance grading out to fine sand and silt at the outer edge of the fan. However, there are identifiable strata which reflect the activity of the water.

The deposit may exceed 100 feet in depth near the stream channel where the material is coarse. The depth always diminishes away from the channeled stream.

These land forms are situated at the base of mountain ravines and gullies. Occasionally a series of alluvial fans will coalesce into a formation called a piedmont plain. This formation, of course, offers more extensive deposits of sand and gravel.

The slope and material gradation are significant factors of an alluvial fan.

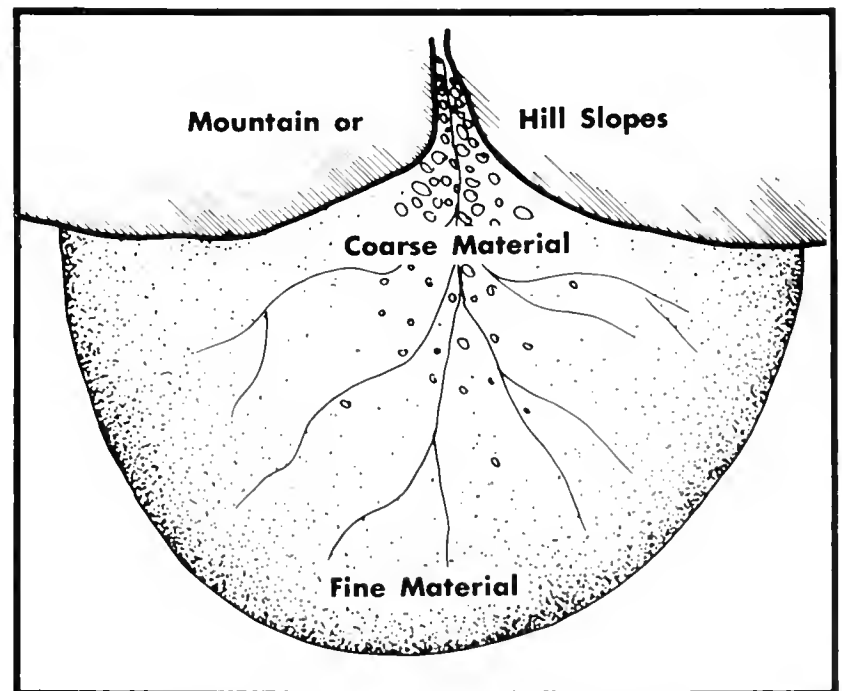
#### Alluvial Terraces

Alluvial terraces are formed by water cutting into old flood plain deposits of considerable depth. They are similar to the glacial valley-trains, as re-occurring torrents of water eroded away previously deposited material. (Fig. 14)

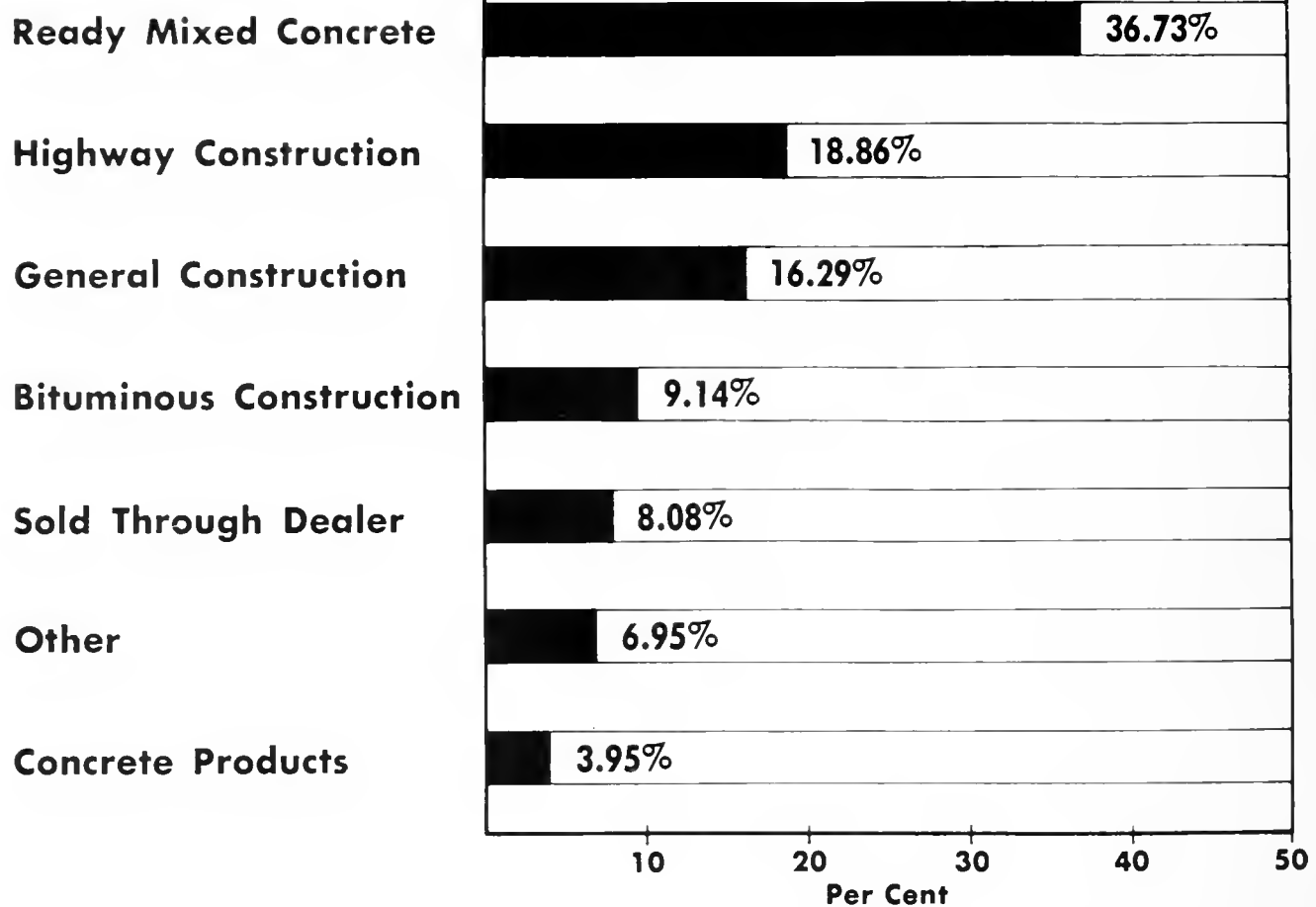
Flat topped terraces, several hundred yards wide are formed at various elevations. The terraced bank may rise 100 feet above a lower terrace or the river bottom. Material characteristics are as described in the section on flood plains.

#### Deltas

The fluvial delta is similar to the glacial delta formation except that it is likely to cover a larger area. It is a less significant source of sand and gravel however, because it is composed primarily of fine sand with a high percentage of silt and debris present.



**Fig. 16 – Plan of an Alluvial Fan**



**Fig. 17 — Consumption of Sand and Gravel in 1963**  
(From Production and Value of Sand and Gravel in 1963)

## Chapter 2

# Site Location

In the previous chapter, the type of deposits and their distribution have been discussed. As stated, many sections of the country are adequately endowed with sand and gravel bearing land forms. This chapter is concerned with factors that influence the location of a sand and gravel operation.

Sand and gravel is a non-renewable resource that is formed and deposited by nature. Man cannot manipulate the patterns in which these deposits are located. The location of any extractive site is restricted to the boundaries of the sand and gravel bearing lands. No sand and gravel pits exist outside these boundaries. However, the presence of quality deposits does not insure their accessibility for development. In addition to the natural limitations, supply and demand, transportation and land use considerations impose significant plant location restrictions.

## Supply and Demand

Demand for this natural resource originates primarily from populated areas where construction of highways, residential, commercial, and industrial developments are most active (Fig. 17). This demand prods the development of the closest available deposits. The distance between the extractive site and the consumer is regulated by the supply of local deposits. When this supply is limited, increased demands will hasten its depletion, which will necessitate development of deposits more remote from the market area, which will in turn increase the cost to the consumer. Additional demand will naturally extend the distance from plant to consumer.

## Transportation

Sand and gravel is a bulky, low-cost product that cannot be transported great distances without substantially increasing the cost of the product. An average truck hauling rate is \$.05 per ton-mile. As a result, most of the material is transported within a thirty mile range of the market area. (Other factors, such as lack of deposits, increase this hauling distance. For example, sand and gravel is hauled up to 100 miles to meet the needs in Houston, Texas.) Little interstate movement exists. Abundant supplies in Minnesota or Wisconsin have little or no value to consumers in Georgia. Consequently, plant sites are located as near to the market areas as other conditions permit.

Trucking is the primary mode of transportation, accounting for about 78% of all hauling in 1963. Meanwhile about 14% of the sand and gravel is shipped by rail and the remainder via waterways, according to the National Sand and Gravel Association (Fig. 18). Originally, rail shipments were the major transportation media. (In some states such as Alabama, Oklahoma, and North Carolina it remains the major form of transportation. Unequal and limited distribution of sand and gravel deposits influence this situation.) However, as highway facilities improved, truck capacities increased, and rail freight rates increased, rail movement declined to its present level of activity.

## Land Use Considerations

The manner in which land use regulations affect the location of a sand and gravel operation depends upon the provision of



the zoning ordinance. Generally, current zoning ordinances contain either or both permissive and prohibitive mineral extraction regulations. That is, few ordinances establish natural resource districts for the primary purpose of excavating existing sand and gravel deposits. Los Angeles County has such a district, and a few other localities including Denver, Colorado, and Fairfax County, Virginia, are attempting to establish natural resource districts to protect existing deposits from encroachment by other uses.

There are basically two types of permissive zoning insofar as sand and gravel operations are concerned. (1) The operations are allowed as a matter of right in specified zones, such as agricultural or industrial districts. (2) Operations are permitted not as a right but as a conditional use or special exception in designated zones but are subject to the approval of the zoning authority and whatever conditions attached as permitted in the zoning ordinance. Various procedures, performance standards, and restrictions are prescribed in both types of zoning.

Prohibitive zoning specifically eliminates the right to extract sand and gravel within defined districts, as a use that is incompatible with designated land uses. The presence of valuable sand and gravel deposits has limited influence on the establishment of this type of zone.

Zoning in populated areas is more prohibitive and has a greater influence in determining the location of an operation. Although examples of prohibitive zoning have been encountered by the sand and gravel industry in remote rural areas, zoning is usually less restrictive and does not significantly affect the location of a sand and gravel operation.

In the limited survey conducted as a part of this study, it was noted that sixty-eight percent of the sites are located within zoned districts and that eighty-four percent of the urban suburban situated sites are zoned. This figure confirms the prevalence of land use controls in populated areas. There is little doubt that as populations increase and more uses compete for less land, zoning will have a greater influence on more operations.

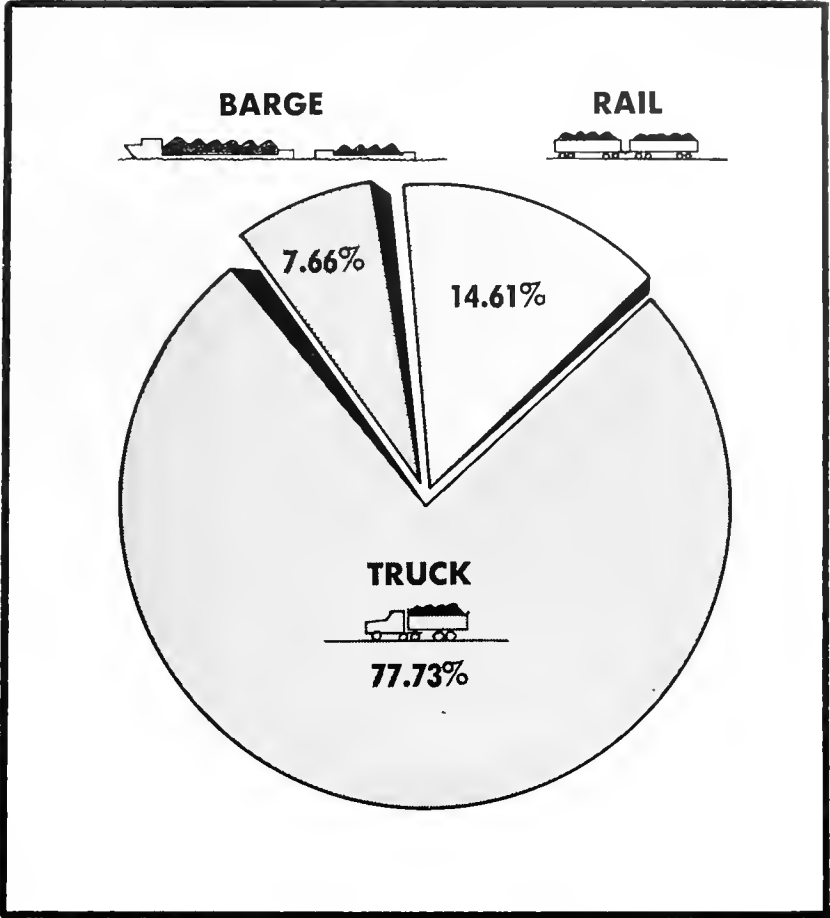
**Location Patterns**

According to the results of the questionnaire, one-half of the plant sites were located in urban-suburban areas and the remaining sites in rural areas. However, further research indicates that a number of these rural sites are situated on the perimeter of the suburban areas and are therefore within the influence of the suburban environment (Fig. 2). A concentration of excavation activity occurs in the zone between the rural and suburban areas. The number of operations diminish, due to transportation cost factors, in the direction of the remote rural areas, and also diminish, due to land use regulations, in the direction of heavily populated centers (Fig. 19).

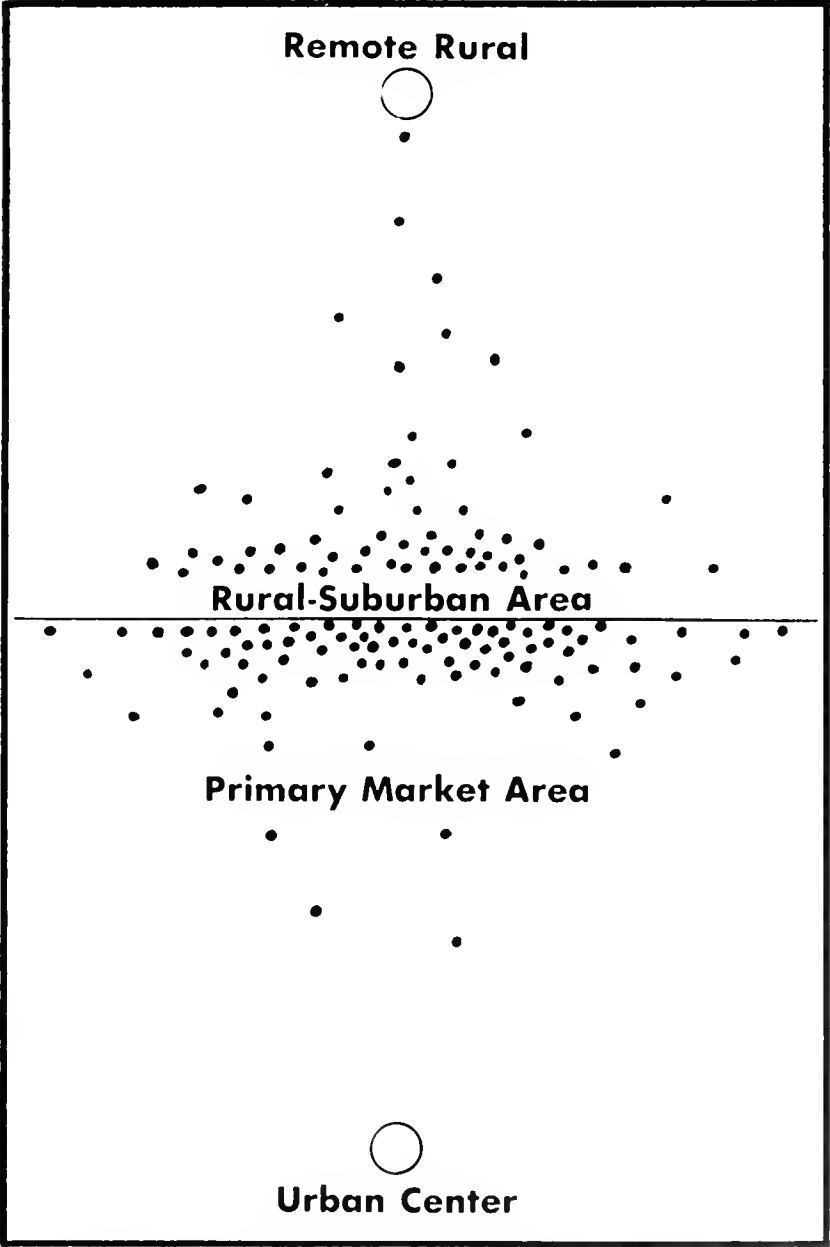
**Plant Size**

Although the size of an operation does not influence the location, the location does affect the size. According to the sample survey, the average acreage in the rural area was 650 acres per site while in the urban-suburban areas the average site was 250 acres. The sizes of the sites ranged from 10 to 3000 acres with 13 percent containing less than 100 acres, 60 percent between 100 - 500 acres, and 27 percent over 500 acres. Because of the survey limitations, it is felt that these areas are larger than the average site.

The size of the operation is limited by the deposit boundaries, property lines, and easements of various kinds. It is also limited by surface development, particularly residential and commercial, as they encroach and eventually surround the operation. In addition, zoning regulations limit the size by defining land use districts that do not conform to deposit formations, by defining minimum acreage, and by establishing lengthy setback restrictions.



**Fig. 18 — Transportation Chart**  
(From Production and Value of Sand and Gravel in 1963)



**Fig. 19 — General Pit Distribution Patterns**

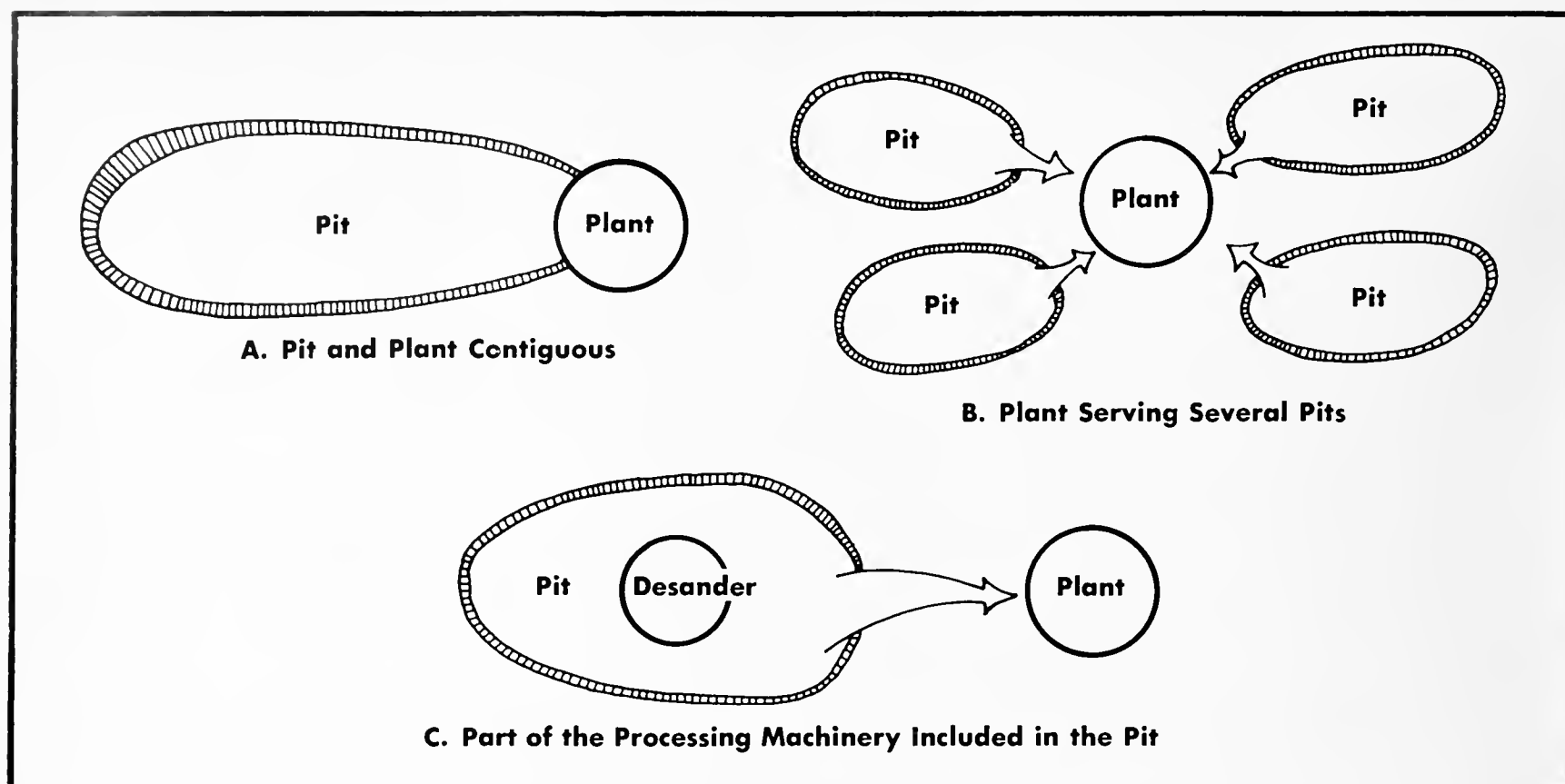


Fig. 20 — Pit-Processing Plant Relationship

## Chapter 3

# Operational and Site Characteristics

Every sand and gravel operation is a unique development resulting from a variety of site, equipment, and environmental characteristics. Composition, quality and quantity of material, market, desired plant capacity, topography, and zoning are some rudimentary factors that contribute to the individuality of plant design and resultant site conditions.

The major elements of sand and gravel operations and resultant land forms are recorded in the following pages. A review of specific site and operational features is completed in the case studies.

## Types of Operations

There are two basic types of sand and gravel excavations: wet and dry, the type conducted being related to the type of sand and gravel bearing land forms. Wet excavations are common in outwash plains, lower levels of valley trains and alluvial terraces, deltas, and flood plains; whereas, dry excavations are prevalent in esker, kame, alluvial fan, and valley train formations, but are conducted in most land forms when there is considerable deposit depth above ground water line.

A particular site may require either, or a combination of both types of operations. Often a dry excavation will proceed for a number of years, until the layer of material above ground water is removed, followed by a wet excavation. Or, both types of excavations may be operated concurrently. According to the sample survey, 50 percent of the operations involved wet excavations.

## Duration of Operation

Anywhere from one to twenty acres are excavated per year at a given site. Although the total acreage is a basis for deter-

mining the life of a deposit, the deposit depth affects the number of acres excavated annually.

Another influencing factor is the composition of sand and gravel. When the sand content is high (60-80 percent) a great amount of material must be handled to obtain the desired coarse aggregates. The demand for sand and gravel and local supply also affect the life of an operation.

## Pit-Plant Area Relationship

Most sand and gravel sites include excavation and processing areas. These two units of activity are generally separated to some degree, but are directly related to each other in the total operational scheme. They may be situated together in a pit area; part of the processing machinery may be included in the pit; or the two areas of activity may be separated by distances of up to several miles (Fig. 20). Size of the site and the number of sites under the control of a single operator affect the pit-processing plant relationship.

## Procedure and Sequence

There are four basic steps in a sand and gravel operation. They include:

1. Stripping overburden.
2. Excavation.
3. Transportation — from pit to processing plant and from processing plant to market.
4. Processing.

### 1. Stripping overburden.

This process simply involves the removal of any material covering the deposit and either redepositing it elsewhere on the

site or transporting it off the site. Not all the overburden on the property is removed at once. Generally only an area covering the anticipated yearly excavation is stripped. Often the remaining area contains whatever use existed before excavation activity was initiated such as raising various agricultural crops. Occasionally, either by choice or in compliance with local regulations, the topsoil is separated from the overburden and stock-piled or sold to local nurseries and home owners.

#### 2. Excavation.

Excavation involves the removal of material from the sand and gravel deposit for transport to the processing plant. The manner in which this operation is accomplished is related to pit characteristics, type of equipment utilized, cost, and often on the basis of the producers experience.

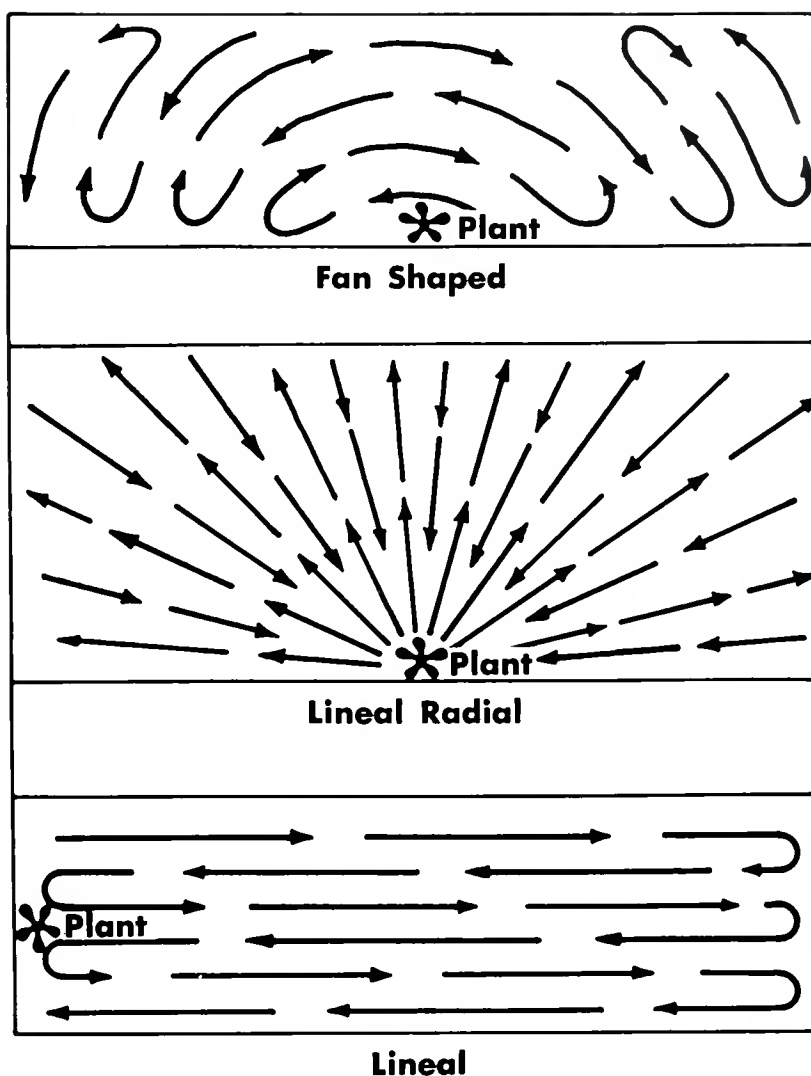
Excavation generally occurs in patterns away from the processing plant. However, in some sites it begins at the far end of the property and progresses to the processing plant area. These patterns represent fan shaped, radiating lineal, lineal, or erratic forms (Fig. 21). An element that disrupts a pattern of excavation is the presence of an unmineable deposit. This deposit may be removed or circumvented, depending on its size and the nature of the unmineable material.

#### 3. Transportation — from pit to processing area and from processing area to market.

Depending on the type of equipment, the raw material is transported to the processing plant directly from the excavating machine, or it is hauled from a surge pile deposited near the point of excavation. Material transported from the processing plant area to the market is usually moved by vehicles owned by persons other than the sand and gravel producer.

#### 4. Processing.

The processing plant is the heart of a sand and gravel operation. It is designed to process the material in the particu-



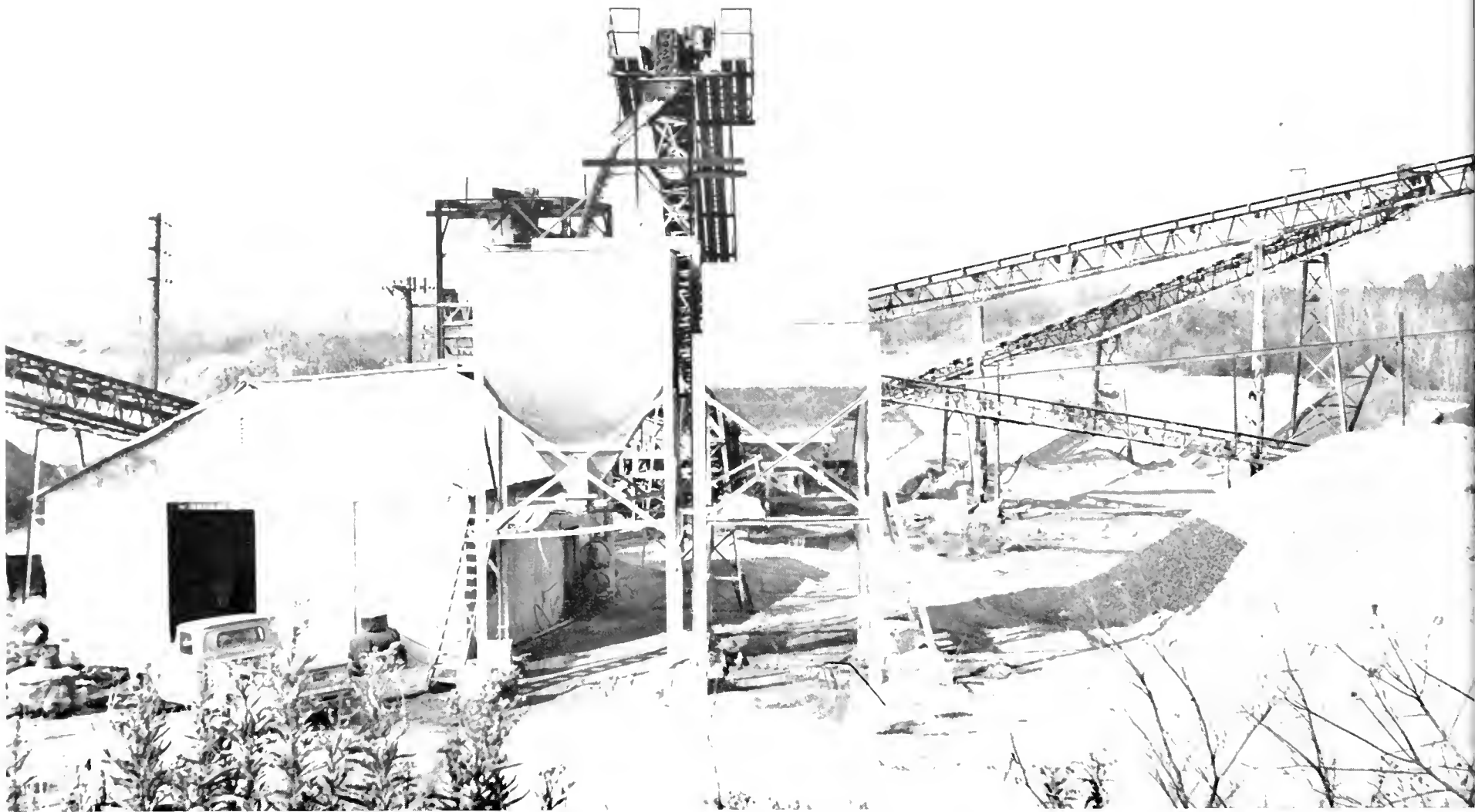
**Fig. 21 — Excavation Patterns**



**Fig. 22 — Dredge**

**Fig. 23 — Dragline**





**Fig. 24 (1) – Structural Characteristics of the Plant Area**

**Fig. 24 (2) – Structural Characteristics of the Plant Area**







**Fig. 25 — Portable Plant**

lar deposit into products that will meet local demands and specifications. Crushing, screening, washing, and stockpiling are all part of a normal operation. Material is dumped either from the transporting vehicles into the plant or the material is deposited on a surge pile for processing at a later time.

## **Equipment Characteristics**

Each procedure in the sand and gravel operation requires the type of equipment that is best suited to accomplish that particular task, under the set of conditions that exist in and around the deposit. Some of the equipment is utilized for several different operations as described in the following section.

### *1. Stripping Overburden.*

Equipment utilized in the stripping operation includes carryalls, front-end loaders, scrapers, and draglines. Depth of overburden, excavating procedures, ground water elevation, and redepositing objectives all have a bearing on the type of equipment selected. Hauling distance and the number of times the material is handled are also significant criteria.

Carryalls, scrapers, and front-end loaders remove the material from the area of excavation to points on or off the site. These pieces of equipment have considerable leeway in regard to redepositing the material. When a dragline is used, the redeposit of this material is limited to windrows near the excavation point, in the unexcavated areas, or in the recently excavated site. However, the use of such transporting vehicles as trucks and carryalls, in combination with the front end loaders or dragline permit a greater hauling distance and more choice in depositing the material.

### *2. Excavation.*

Excavation equipment can be grouped into three categories:

- a. That which excavates below water line.
- b. That which excavates above water line.
- c. That which excavates above or below water line.

The dredge is one of the common pieces of equipment used in a wet excavation (Fig. 22). Large area, deep deposits, and material that is not too coarse are criteria for selecting this piece of equipment. It can normally excavate to depths of

60 feet below water but in some cases this has been extended to 80 feet. Material above water can be excavated by forcing the bank material to fall into the water area.

The dredge usually operates in a fan shaped pattern away from the processing plant. It is somewhat restricted to this pattern by the pipeline in which the excavated material is pumped to the shoreline. However, it can be operated in almost a 360 degree radius.

Power shovels and tractor-scrappers are types of equipment used in a dry excavation. The power shovel being more common in the deep deposits while the tractor-scraper is best adapted to the excavation of shallower deposits. Neither of these units of equipment maintains a particular pattern of excavation and both have considerable freedom of movement in their excavation progress.

Draglines and slack line cableways operate in both wet and dry pits of which the dragline is most commonly used (Fig. 23). The dragline has considerable ease of movement but generally operates in fan shaped patterns away from the processing plant or lineal patterns radiating from the processing area (Fig. 26). It excavates material to 40 feet below water line.

A slack line cableway is a scraper bucket attached to a cable that is supported by a permanent mast of up to 100 feet in height, in the processing area and a portable "dead man" up to 700 feet from the permanent mast. A wide area is covered by shifting the "dead man". However, in comparison to other methods the cableway is a less flexible method of excavation. Also, ridges of material are left behind for excavation by other methods.

### *3. Transporting — from pit to processing plant and from processing plant to market.*

The methods of transporting material are selected on the basis of site conditions and the operator's preference and experience. Belt conveyors, pipelines, trucks, carryalls, and sometimes trains are used to move the material from the pit to the processing area. Many times a combination of transporting methods are used. For example, material piped from a dredge may be deposited in a surge pile on the shoreline and conveyed by belt from the pile to the processing plant.

The pipeline is a less flexible method of transporting material



**Fig. 26 (1) – General Pit Patterns**

**Fig. 26 (2) – General Pit Patterns**







**Fig. 26 (3) —  
General Pit Patterns**



**Fig. 26 (4) —  
General Pit Patterns**

**Fig. 26 (5) —  
General Pit Patterns**







**Fig. 27 – Visual Dominance of Pit Wall**

than other types of equipment but is the most efficient method when utilized in conjunction with a dredge. Material is conveyed to the shoreline in a pipeline floating on pontoons. This pipeline can be made flexible by installing rubber-like elbows between the forty foot sections of pipe. With the inclusion of booster pumps, material can be conveyed more than 1200 feet from the dredge.

The belt conveyor allows a little more flexibility than the pipeline but its big advantage is low transporting costs. In some operations a belt system extends several miles. The tracks come in various lengths and the direction of haul can be changed by adding a hopper at the point of directional change.

About one half of the sites reported in the questionnaire used trucks and scrapers. Trucks are often used to carry material from pit to processing plant when the plant is separated from the pit area by several miles.

Transportation of material from plant to consumer is accomplished by truck, rail, and water. (See Chapter 2 for

percentage breakdown of these three modes of transportation.)

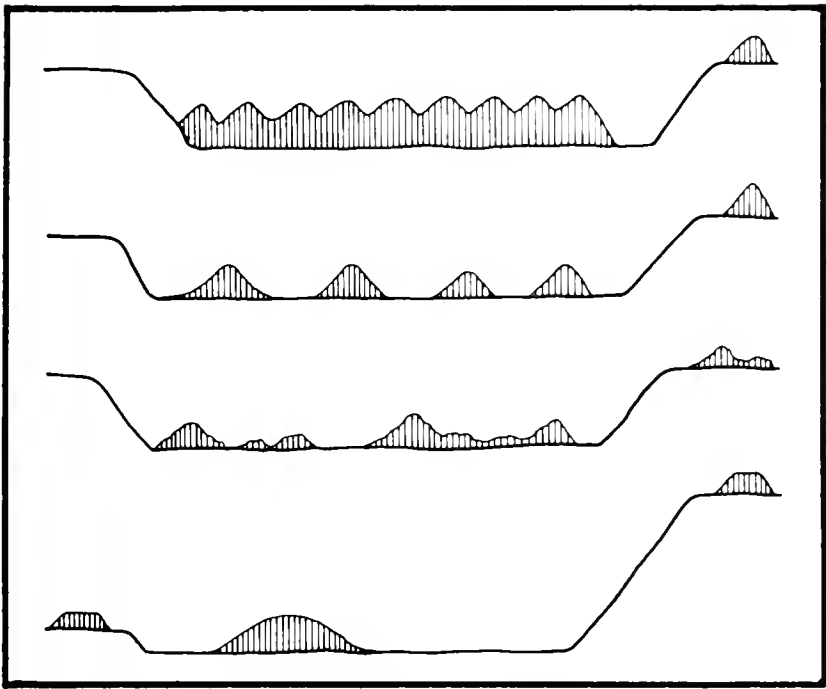
#### *4. Processing.*

The processing plant is a combination of equipment forming a unit that will achieve a specific output and produce specific grades of material. It contains a network of screens, crushers, classifiers, desanders, stackers, conveyors, hoppers, and loading and unloading equipment (Fig. 24). There is little standardization of plant design as each is fitted to the particular situation. One processing unit may be compact while another of similar capacity may be a sprawling complex of steel framing and structures, underlaid with pyramids of sand and gravel.

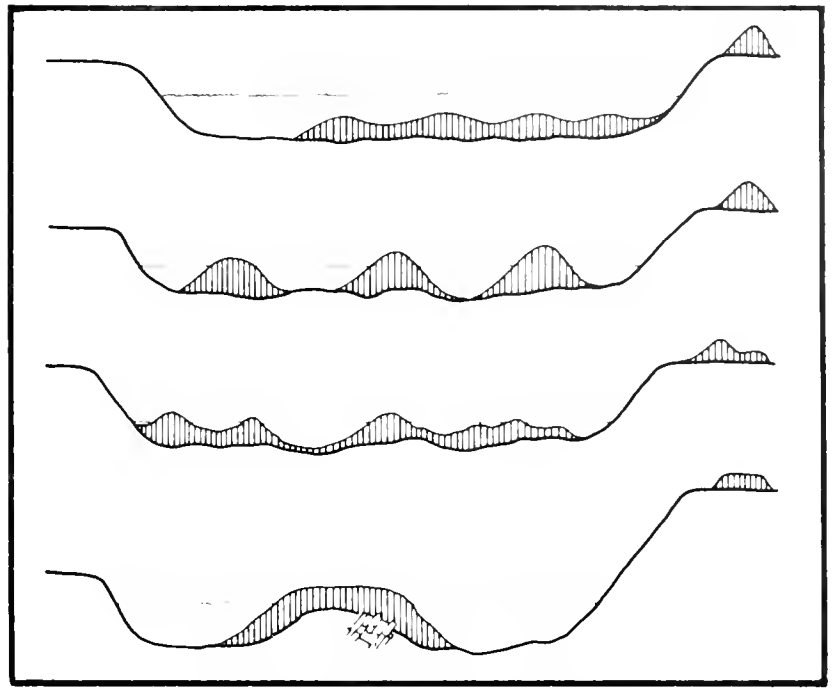
Part of the processing unit may be separated from the plant area. The desander, which is installed to remove sand that is in excess of local demand, is sometimes located in the pit area away from the main processing plant. As such, it is a semi-portable unit that is periodically moved closer to the point of excavation. It is often associated with a wet operation and with a dredge. Material processed through the desander is

**Fig. 28 – Cut Slopes**





**Fig. 29 (1) — Overburden Formations — Dry Pits**



**Fig. 29 (2) — Overburden Formations — Wet Pits**

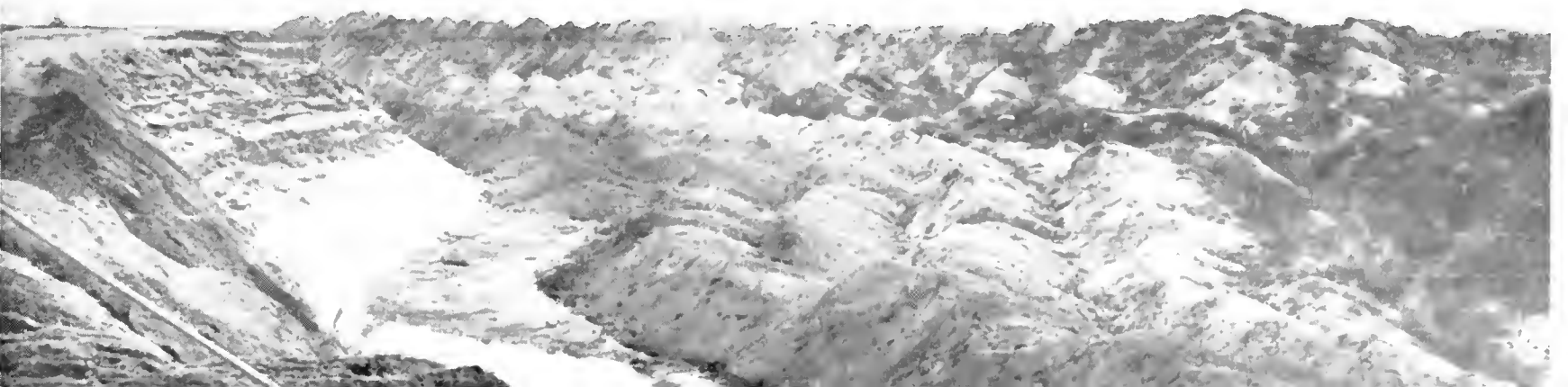


**Fig. 29 (3) — Overburden Formations**



**Fig. 29 (4) — Overburden Formations**

**Fig. 29 (5) — Overburden Formations**





**Fig. 30 (1) – Waste Sand Formations**



**Fig. 30 (2) – Waste Sand Formations**

either stored in a surge pile, for conveyance to the plant at a later time, or it is conveyed directly to the processing plant. The excess sand is dumped near the desander but can be piped considerable distances from it. The waste sand can be likewise deposited when the desander is a part of the main processing plant.

In addition to the main processing plant, portable plants are often utilized (Fig. 25). These units maintain limited outputs, and produce a limited range of specification material. This type of plant may consist solely of a crushing and screening unit or it may be composed of a complex series of assembled portable units. These units are used in conjunction with the main processing plant, or they are the main processing plants for small, short term operations.

## Site Conditions

### *Processing plant area:*

In addition to the processing equipment, the processing plant area contains the storage area for equipment and materials, service and office buildings, waste and disposal areas, and sedimentation ponds, and is the hub of activity insofar as sales and transportation of finished product are concerned.

Normally the plant area is between 10 and 20 acres, but the size ranges from 2 to 90 acres. Size of total operations, plant capacity, plant design, and stockpiling methods influence this size.

One of the primary factors for locating the plant area is access to rail and improved roads. Direct access to major highways is desired and despite other unfavorable site location conditions is often the overruling location factor. The character of the deposit also has a bearing. That part of the deposit, with due consideration for access, which contains the poorest or the least amount of commercial material is the most desirable plant location. In addition, relationship to the excavation area, areas

required for waste sand and sedimentation ponds, and the size of stockpiles influence the location. Zoning is also emerging as a basis for selecting a plant area with its various set-back and screening requirements.

### *General pit patterns:*

Many pits illustrate strong patterns created by the excavation process and by the redeposit of overburden and waste sand. The wet pits display the most prominent patterns while the dry pits display an erratic appearance (Fig. 26). Generally the overburden patterns are lineal and the waste sand deposit is fan shaped. Other than these patterns, the conditions in the pit suggest an undisciplined excavation process and an erratic disposal of waste material. Steep banks, shallow bodies of water, small pockets of water, stagnant bodies of water, and piles of waste material are the elements that create the character of existing pits.

### *Slopes:*

The slope of the cut bank often creates the most profound impression of a pit because it does not represent any natural slope and because it enframes the hole in the ground (Fig. 27). The height of the bank has a significant bearing on this impact. It may rise to more than 100 feet above the pit floor.

Freshly excavated banks often hold their vertical form for several years, until frost, rain, and wind aggrade them. The angle of repose for a bank in a gravel pit is from 1:1 to 2:1 (Fig. 28). Unless some effort is made to spread topsoil and seed, vegetative growth is scarce and weedy to non-existent.

### *Overburden Deposits:*

Overburden piles exist in windrowed pyramids and erratic non-descriptive heaps of various heights and in various locations on the site. It is deposited along the perimeter, in the excavated portion of the pit, or on lands within the property that contain material of low commercial value (Fig. 29). In wet pits the overburden protrudes from the water, creates shallow water areas, is dumped into deep bodies of water, or is used





**Fig. 31 (1) — Shallow Water Area**



**Fig. 31 (2) — Shallow Water — Remnants of Land**

to fill in shallow water areas. In all cases overburden is handled as few times as possible and is transported the shortest distance possible.

*Waste sand deposits:*

When deposits contain more sand than the local market demands, it is separated from the coarse aggregate and pumped into heaps near the processing plant or redeposited into the pit by a desander located near the point of excavation (Fig. 30). In some deposits 45 percent of the material excavated is redeposited in the form of waste sand.

When the material is dumped into the pit, it usually forms a fan shaped land form with 5 to 20 percent slopes. The size of this land form depends upon the size of the deposit, the permanency of the desander, the depth of the pit in the area that the sand is deposited, and the amount of sand in the deposit.

*Residual formations:*

Residual formations are deposits of clay, rock, silt, and other material not suited for mineral extraction which are skirted by the excavation process. These formations are located at various elevations within the deposit and may extend the entire depth of the deposit. If, however, these deposits cover valuable sand and gravel, and if they are not too large, it is likely the undesirable material would be stripped away.

These formations exist in various sizes and shapes and may on occasion have a significant impact on the pattern of operations and on the resultant pit characteristics. They may be a mountainous formation arising from the floor of a deep pit;

they may reduce the depth of a pit, or they may exist in the form of peninsulas or slivers of land extending into the pit area.

*Vegetation:*

Vegetation in most pits is sparse consisting of weeds, grasses, and various types of weed-like trees and shrubs. However, in a combination of water and overburden of suitable fertility, plants do grow rather vigorously. Water is a very significant growth factor as demonstrated by the rapid and dense growth of plant material along shorelines and in pit floors that are just above ground water elevation.

*Water Areas:*

As previously stated, 50 percent of the surveyed sites contained water. In these sites the water either covers the whole pit area, part of the pit, or exists in small pockets within the pit. It may be a large unbroken body of water, or it may be segmented by various land forms, (natural and deposited).

The water depth is extremely variable. It ranges from two to sixty feet. Frequently, even when the whole site is covered by water, it is shallow with exposed or partially exposed land surfaces. Any fluctuation of the water table exposes additional land and leaves isolated pockets of water (Fig. 31).

Overburden is often dumped into the water area forming windrowed islands, bays, and shallow stagnant bodies of water. If, however, the overburden is shallow, or if there is a need to remove it to the pit perimeter, or if the water is deep and overburden dumped into it will not reach the surface, a large unbroken body of water is likely to be formed (Fig. 32).

**Fig. 32 — Large Open Body of Water**





**Fig. 33 (1) — Rehabilitation — Campground & Fishing**



**Fig. 33 (2) — Rehabilitation — A Ballfield**



**Fig. 33 (3) — Rehabilitation — Residential**

## *Chapter 4*

# Current Rehabilitation Practices

Rehabilitation of sand and gravel deposits is not an unknown effort in the sand and gravel industry. Many depleted sites have been turned into functional land areas, some of which have become a very definite asset to the industry and the community. Some of these projects are illustrated in the National Sand and Gravel Association's publication "Case Histories." The types of projects range from private residential and commercial developments of the highest quality, such as the North Columbus water-oriented commercial development in Columbus, Ohio, to public facilities that include parks and playgrounds, sanitary land fills, and water purification settling ponds. In Dallas, Texas, a sewage disposal plant was constructed on a 70-acre site through the cooperation of the city and the sand and gravel producer. The plant will eventually expand to adjoining pits. Many more types of projects have been developed when a suitable combination of need and site facilities existed.

## **Criteria for Rehabilitation Activity**

As population expands and land use becomes more intense, three criteria for a rehabilitation program emerge.

1. Public pressure.
2. Regulations.
3. Direct or indirect financial gain (land value).

One of the basic objectives of a rehabilitation program is to improve the industry's public image. The public is becoming more vocal in its opposition to sand and gravel operations. With increasing frequency the public objects to the presence of an extraction industry on the basis of past experience and existing conditions. Many sections of the country are pocked with abandoned pits of various sizes, shapes, and forms of dereliction. As land use becomes more intense, these old pits become a more dramatic example of the industry's apparent attitude





**Fig. 33 (4) — Rehabilitation — Public Beach**



**Fig. 33 (5) — Rehabilitation — Industrial Park**

**Fig. 33 (6) — Rehabilitation — Residential**





**Fig. 34 — A Sportsman's Club — An Unimproved Gravel Pit**

toward land. In order to alleviate public resentment the producer must reduce the friction between the site and operations and the surrounding area, and he must improve the appearance of the excavated lands.

A tool of public expression, in terms of land use and development, is the zoning regulation adapted by various levels of government. The sand and gravel industry is particularly affected by the local town, county and municipal zoning regulations.

In conjunction with permitting sand and gravel operations in specific districts, zoning regulations define performance standards aimed at eliminating the creation of objectionable operational characteristics, and undesirable land forms. Compliance with these regulations is a criterion for establishing a land development program but generally does not assure the creation of a functional land use. Some of these requirements are recorded in the section "Performance Standards" in this chapter.

A third criterion for land rehabilitation is land value. A responsible land use program becomes an attractive incentive when a potential economic gain is realized. Very significant increases in land values have been achieved through rehabilitation efforts as illustrated in existing projects. In the North Columbus project the land was purchased at \$400 an acre and sold as rehabilitated land for \$3,500 an acre. In Michigan a 60 acre tract, consisting partly of swamp land, was developed into a water oriented recreation area with the land value improving from \$50 to \$250 per acre. Another producer in New York increased the value of his land from \$4000 per acre to more than \$12,000 per acre by developing a quality residential area in the depleted site. It has been expressed by some producers that if they can "break even" or even take a slight loss on rehabilitation work, they have gained indirectly, as long as their public image is improved, and if access to future sites becomes less of a problem.

## **Performance Standards**

Local ordinances have established a wide range of rehabilitation standards, from a detailed restoration plan, (usually a grading plan) to simple slope requirements. Also included in these performance standards are stockpiling methods, planting and screening plans, limitations on depth of excavation, and handling of topsoil.

A provision in the Salt Lake County ordinance requires recontouring to begin as soon as practical to eliminate unnatural remains and encourage vegetation to regrow. An ordinance in Wisconsin requires appropriate planting of trees and shrubs "... to enhance the general appearance from the public right-of-way, and generally to minimize the damaging effect of the operation on the beauty and character of the surrounding countryside."

Many of the performance standards contain provisions requiring preservation and respreading of topsoil. Most stipulate that topsoil will be respread to the depth that originally existed. Another common provision requires that cut slopes will not exceed the normal angle of repose.

In addition to other detailed restoration regulations some ordinances require that a restoration plan be submitted before an extraction permit is issued. Grading plans, planting plans, proposed land features, and methods of restoration may be required in this plan.

## **Types of Rehabilitation Projects**

The range of uses that can be applied to depleted sand and gravel sites is only limited to the number of uses in existence. Although, until recently, activity in land rehabilitation has been limited, a wide variety of land uses are already completed. No general land use category remains untapped. Residential, commercial, industrial, recreational, and agricultural developments are completed. Land areas are being developed for both public and private interests.

Currently most uses are being developed in the wake of a demand for the particular features that a pit has to offer. However, one type of pit is not limited to certain types of land uses. In a given situation any number of uses can apply, depending of course on various influencing factors.

In general, however, pits that contain large bodies of water offer a special amenity to the market of land uses, especially to recreation and residential development. While pit areas confined by steep, high banks are more suitable for storage areas, industrial sites, and limited recreational use (Fig. 33).

One land use that keeps appearing, but is cautiously mentioned by many producers, is the sanitary land fill. The need for disposal areas is increasing with the population. A deep hole in close proximity to the population centers can fill this





**Fig. 35 – Progressive Rehabilitation**

need. Sand and gravel pits meet both these qualifications to the attraction of public and private sanitary disposal groups.

However, there is a reluctance among sand and gravel people to be associated with this type of use, despite rigid sanitation restrictions on type and compaction of the waste material. The sanitary land use offers a profitable interim use that can eventually develop into a profitable ultimate use such as a recreation, parking, or storage area.

## Approaches to Rehabilitation

Currently, three types of rehabilitation programs are utilized.

1. Little or no restoration effort because of a combination of unique pit characteristics and demand from a special interest group.
2. Restoration work after a site is depleted.
3. Progressive rehabilitation.

### 1. A depleted site requiring little or no restoration effort:

Occasionally, due to a variety of circumstances, the extractive process will create pit characteristics highly suited to meet the requirements of a specific use, even though it operated outside the realm of a land development program. A case in point is a wet pit in Illinois that has been leased to a private sportsmen club.

Windrows of tree and shrub covered overburden protruding above the water create isolated bays, and form the character of the pit (Fig. 34). Water fowl take cover in these bays which are also good fishing locations for the fish stocked by the club. Because of a rapid vegetative regrowth, many of the scars are covered up. Yet, the derelict appearance remains as weedy sand bars (partially submerged, depending on the water fluctuation), steep slopes, and several exposed waste heaps identify the results of a sand and gravel operation. Although

the use and special opportunities offered by this site are noteworthy, the general appearance of the site is objectionable.

### 2. Restoration work after a site is depleted:

A rehabilitation project initiated after excavation has terminated generally involves grading and planting operations. Unless demand warrants it, no special effort will be made to create and mold the most useful and functional land areas. Banks of overburden too steep, too high, or too shallow, slivers of unusable land, banks cut too high, and water areas too shallow are elements that the rehabilitation effort must overcome. Examples of this type of rehabilitation work illustrate segments of wasted land, and undesirable features such as stagnant water, or muddy flats resulting from fluctuation of the water table.

### 3. Progressive rehabilitation:

Currently, several progressive rehabilitation projects are active without the direction of an illustrated plan or a determined land use. This rehabilitation approach usually takes into account reduction of noise, dust, and visual conflicts by appropriate screening. It also eliminates the creation of undesirable pit forms (Fig. 35).

Progressive rehabilitation involves grading, (usually to mowable slopes) planting and seeding depleted areas as soon as practicable. Normally most rehabilitation activity occurs during the slack times of the approaching winter. However, some of the work is completed during the summer months as equipment is available.

Progressive rehabilitation is the accepted approach among the producers interested in developing a rehabilitation program. Elimination of waste heaps, more efficient use of waste material, and general reduction of objectionable operational characteristics are cited as the result of such a program.

These three approaches to rehabilitation are the most common. However, there exist several examples of a detailed and studied approach to rehabilitation. One of these controlled



**Fig. 36 — Planned Development — A Residential Area**

systematic excavation and development programs is currently underway in Indianapolis, Indiana (Fig. 36).

### **A Planned Development**

It is a 60 acre tract situated near the White River. The land is low and subject to spring floods. Between the river and two sides of the site are year-around river front homes. On another side, a quality residential area overlooks the property from higher ground. The site is bordered by a limited access highway on the fourth side.

The deposit is approximately 40 feet deep and contains about 50 percent sand. Extending in from the property line farthest from the highway is a vein of material unsuited for excavation.

The operations include dredge, desander, conveyor belt, pipeline, and dragline machinery. The dredge excavates the material, and pumps it to the desander. The desander separates the aggregates from the sand, pumps the excess sand into the site and conveys the coarse material through a tunnel under the highway to the primary processing plant, one mile away. The dragline strips and stockpiles the overburden.

A plan for a water oriented residential site with the land area elevated above flood stage is developed. A unique and promising adaptation of site and operational conditions is being achieved. Deposition of overburden is designated around the site perimeter and around the unmineable peninsula to form a dike, the objective of the dike being to contain the sand pumped within it, to maintain desired slope and land form, and to elevate the land area. Sand is also deposited along the highway right-of-way to form adequate residential land areas.

The dredging operation proceeded in a pattern that first facilitated placement of sand along the highway. Concurrently the overburden dike was being formed. After the land area along the highway was completed, the sand was deposited into

the diked area. The sand is pumped a maximum distance of 1000 feet. Previously stockpiled overburden will be spread over the sand areas, graded and seeded.

The result of this operation is the development of the highest site potential and favorable public relations.

### **Techniques**

Rehabilitation activity involves handling large quantities of waste material, grading, planting, and screening. Its objectives are to improve the land features and reduce objectionable operational characteristics.

#### **Waste Material**

Overburden is a major element in a rehabilitation program. It is used as a fill material for creating land forms, as a base for plant materials on the floor of the pit, as a sealing and compacting material in a sanitary land fill operation, and as a screening element. (Fig. 37)

The overburden is either deposited on the perimeter of the deposit, in the pit area, or on land containing material unsuitable for excavation. When additional land forms are proposed, overburden is deposited in the designated area, or near the designated area, later to be bulldozed and molded into the desired form.

When screening is desired, the overburden is stockpiled to a suitable height, generally along the perimeter of the site. After the screen has served its purpose it is graded into usable land areas.

Occasionally the topsoil is stripped and stockpiled separately. "As we dig, we use the unsuitable material to back-fill along the road to a width approximately 200 feet. We then respread the topsoil which we stockpiled and plant a crop," stated a producer from the East.

Stockpiling overburden is the first step of an operation. But



**Fig. 37 (1) – A Screening Element Produced by Controlled Placement of Overburden**

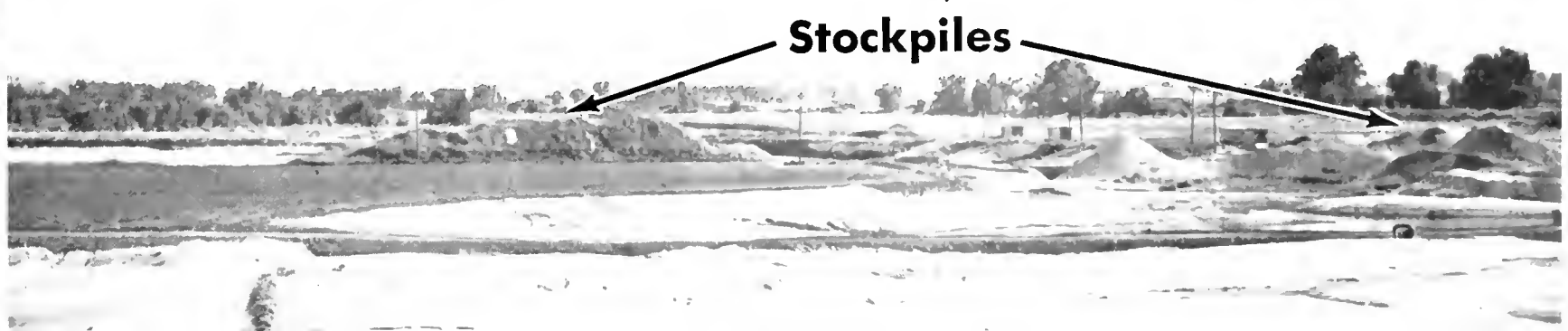


**Fig. 37 (2) – Improved and Enlarged Land Areas by Controlled Placement of Overburden**



**Fig. 37 (3) – Overburden Used to Expand Land Areas Along Pit Perimeter  
Controlled Placement of Overburden**

**Fig. 37 (4) – Overburden Spread Over Pit Floor or Waste Sand Deposits**







**Fig. 38 — Pipeline Used to Create Land Areas**

because only a limited portion of deposit is stripped depending on the area excavated annually, it is a process that moves along with the excavation. However, when certain proposed land areas require large quantities of overburden or certain areas require immediate screening, the material is likely to be stripped from and stockpiled on any part of the site, at anytime during the operation.

Another form of material used in creating land areas is waste sand. Depending on the size of the site and the quality of excess sand, one or more waste sand areas can be created. Considerable flexibility exists in forming waste sand areas due to the maneuverability of the waste sand pipeline and the distance that the sand can be pumped — up to 1200 feet. (Fig. 38)

#### **Grading**

The grading operation in a progressive rehabilitation program begins as soon as possible after an area has been depleted. However, one of the first functions is to grade the overburden stockpile screens to a mowable slope. Following this operation it molds the proposed land forms, smooths out the rough pit floor, and reduces the slopes.

When grading is initiated after a site has been excavated, it often becomes a matter of smoothing the waste heaps and uneven slopes to a rolling mowable terrain.

#### **Planting**

In current rehabilitation practices, planting schemes accomplish four objectives. Plant materials are used to screen the operations from public view, to stabilize the slopes, to recondition the soil, and, to a limited extent, improve the aesthetic value of the site (Fig. 39).

Rows of plant materials such as evergreens are utilized for screening purposes. They are usually planted along the property line about the time the sand and gravel operations are initiated. However, until the plans mature they do not serve their purpose and a lapse of ten or more years often occurs before an adequate screen develops.

Grasses, and legumes, such as alfalfa, are common erosion control elements planted on graded gentle slopes as well as on steep banks. In addition to the stabilization value, they improve the general appearance of an excavated area. Alfalfa is often used as a soil conditioner. In one instance a producer plowed it under to improve the physical structure of the overburden that he spread over the area.

The general appearance of a sand and gravel site is often improved by the presence of plant materials. Several operators have planted material at the beginning of an operation and during their progressive restoration program. As a result mature trees exist on the site even before excavation is terminated. Twenty year old trees add a very significant aesthetic value. From Colorado a producer reports that gently sloping banks are planted with trees, shrubs, and ground covers, "... so that the land will be suitable as building sites when operations cease."

In addition to these planting techniques some operators have converted both excavated and unexcavated land into tree farms. Recently producers in New York State were notified that the state conservation districts will provide seedlings at \$10.00 per 1000 for the purpose of screening objectionable operation characteristics from public viewing and for rehabilitating exhausted deposits. In long term operations, a cash crop of Christmas trees is realized from an area not yet excavated





**Fig. 39 (1) — Seeding the Slopes**



**Fig. 39 (2) — Plants Mature Before Excavation is Completed**

as well as from depleted lands before the operations terminate.

### Methods of Screening Operations

Plant materials and stockpiling are two current screening devices that have been previously mentioned. Some sites contain variations of these two in combination with other techniques.

Occasionally a producer will increase the setback distances from property lines and rights-of-way to a point where the conflicts of an operation are substantially reduced. Zoning ordinances require setbacks or so called buffers that range from 30 to 400 feet. However, in terms of a screening element these figures are arbitrary and often in excess or deficient of the most satisfactory distance.

Another method of screening used by some producers is the purchase of adjacent land for the sole purpose of putting a greater distance between the operations and adjacent land uses. A company in Utah provides an illustration of this point. "It has been necessary for the company to acquire some additional property adjacent to the plant so as to maintain an intermediate area away from subdivision development."

### Limitations

Along with the incentive of a rehabilitation program are several factors that limit the scope and presently discourage the development of such a program. These limitations must be

realized and measured in a planning program.

The following list includes five of the major factors that limit rehabilitation activity in one way or another.

1. Low land values and a limited return on the rehabilitation investment.
2. Lack of grading and earth moving equipment, usually the case in small operations.
3. Extensive and dramatic pit conditions such as deep pits and high banks on extensive shallow bodies of water.
4. Ownership. The results of the questionnaire indicate that operators own 65 percent of the sites, while they have mineral rights on the remaining deposits. There is a natural hesitancy to develop any type of rehabilitation program on leased land unless it is all or partially subsidized by the land owner.
5. Separation of rehabilitation and excavating operations. In this situation, what the excavation creates, the rehabilitation effort must undo.

In relation to the total industry, rehabilitation programs, especially ones that create a land asset rather than a land liability to the community, are the exception rather than the rule. In the eyes of the public, sand and gravel operations mean noise, dust, and scarred landscapes. Many of the existing projects are essentially a fix up of derelict lands that the public has lived with for a number of years.

# Analysis

# Planning Procedures

This chapter is concerned with analyzing the survey information to determine the problems and opportunities in land development and their implications in planning the ultimate use of sand and gravel sites. It involves a review of the prominent conditions and their relationships to each other and will result in a set of recommendations based on this data.

### The Deposit

Sand and gravel deposits are contained within a wide variety of land forms and are composed of material ranging from 90 percent sand to 90 percent coarse aggregates. The deposit depths may be five feet or 200 feet, of which all, part, or none of the material is below ground water line. Forty or more feet of overburden may cover the deposit but five to ten foot depths are most common. Various types and patterns of unmineable material are present in all deposits. They may be negligible or they may involve considerable areas within the sand and gravel deposit.

Sand and gravel deposits occur in two basic land forms — hilly and flat — in which two basic types of operations occur. They are wet and dry. In many sites both types are utilized.

Excavation in hilly deposits is a dry operation that is usually initiated at the base of the hill or at some elevation on the hill that is common with the adjacent terrain. Excavation proceeds primarily horizontally into the hillside. Downward excavation is determined by the deposit size and characteristics. Excavations seldom continue below ground water in this type of deposit unless there is considerable material below water line and the site is large. The resultant pit form is steep-banked on three sides with the height of the bank diminishing toward the initial point of excavation (Fig. 40). These banks may exceed 100 feet in height.

The processing plant is usually near the initial point of excavation but often spreads into the pit area. Its size is somewhat confined by the pit and by the size of operation.

The visual impact of a hillside operation on the surrounding landscape is variable. When an entire hill is reduced it is often extensive and dramatic (Fig. 41). When part of a hillside is affected the pit may either be screened, (Fig. 40) or displayed, (Fig. 42) depending upon its relationship to the surrounding terrain. One pit condition that prevails in hillside excavations is that the operations are fairly well screened from as many as three sides by the hill in which the excavation occurs (Fig. 40). Often the one exposed side is the only area that requires additional screening. However, the fact that the pit walls rise above the immediate terrain, presents some difficulties in achieving satisfactory screening.

In a hillside excavation the impact of the pit is the most impressive part of the operation. Because of the plant location and its physical relationship to the pit environment, the processing plant is less obvious. (Fig. 43).

Small acreage and steep banks present obstacles in the development of this type of deposit. But a variety of uses can be logically applied to hillside deposits, a few of which include: ski and sled runs, rifle ranges, and storage areas.

The extraction of sand and gravel in flat terrain can be either a wet or dry operation, the wet operation being most common. Excavation proceeds down into the deposit below the surrounding terrain, with the processing plant situated above the pit. The result of the excavation is a pit walled on four sides, the visual depth of which depends on the presence and the elevation of ground water. Exposed banks are from a few feet to more than 50 feet.

In flat terrain the processing plant and residual material from the pit are the most dominant features of the sand and gravel operation. Silhouetted against the horizon these features readily identify the extractive site. Unless screened by swales and rolls in the landscape or by some other natural or man-



**Fig. 40 — Operation Area Screened by Pit Slopes**

made obstacles the operation can be viewed from all sides. (Fig. 44) Occasionally, as in the case of a flood plain, the land will be elevated on two sides of the deposit allowing both the pit and the plant area to be fully viewed.

Generally the operations and the depleted site in flat terrain does not have the derelict appearance associated with hillside excavations. Three factors account for this situation.

1. The excavation occurs below the surrounding terrain thereby minimizing the effect of a scarred landscape.
2. More often than not ground water is encountered anywhere from 2 to 20 feet below the surface, which in effect covers up what might otherwise be scattered piles of waste material, etc.
3. Vegetative regrowth is much faster and more profuse because of the presence or nearness of water.

Screening the excavation process is accomplished by either taking advantage of natural barriers or by constructing screens. In either case the objectives are generally more easily accomplished than in the hillside excavation.

#### **Land Forming Material**

In addition to sand and gravel, all deposits contain material unsuitable for processing but useable for building up excavated lands, and for creating additional land surface as in the case of water areas. This material is in the form of overburden that mantles the deposit, and undesirable veins that occur within the

deposit. Some deposits contain large volumes of excess sand, which is available for building land areas. A combination of overburden, unmineable material, and waste sand can, in some cases, exceed 50,000 cubic yards of land forming material per acre. One acre of land approximately 35 feet deep could be created. This is material that must be excavated, transported, and deposited in order to extract and process the desired sand and gravel. Since it is necessary to handle all this excess material, a little forethought in depositing it can represent a very significant land forming potential.

Naturally the amount of non-sand and gravel material is variable with each site. In some sites it is negligible. Generally hilly deposits contain less overburden than those sites in flat terrain, and almost no excess sand.

Excess sand in flat terrain deposit may be as much as 50 percent of the deposit. Also in some of the flat sites overburden may be as deep as 40 feet. These are general conditions that indicate the variation in the amount of land forming material available.

#### **Testing**

Testing, including review of graphic illustration increases in importance when zoning and land development are implicated. The accuracy of determining land use districts and formulating an excavation and development plan will reflect the accuracy of the test information.

Currently test information fulfills the needs of the producer

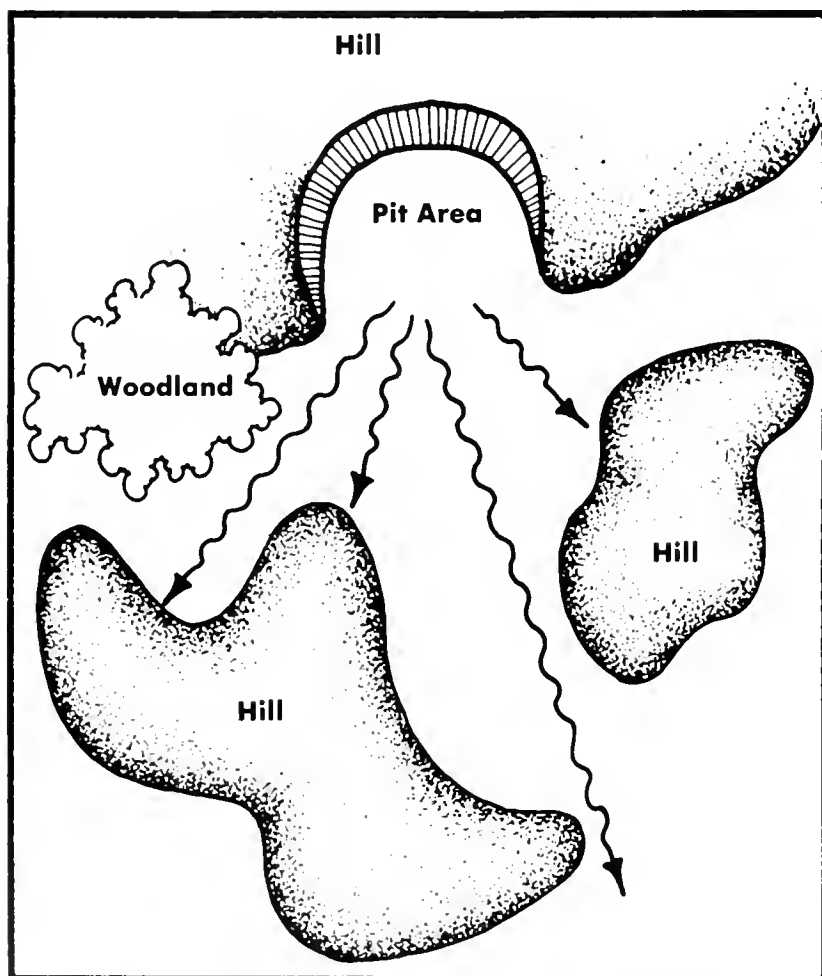
**Fig. 41 — Entire Hill Excavated**







**Fig. 42 – Visual Dominance of Hillside Excavation**



**Fig. 43 (1) – Elements Influencing Visual Impact of Hillside Pit**

in excavating and processing sand and gravel, but it generally does not meet the requirements of detailed and successful planning.

Check list of planning considerations:

#### Hilly Deposit

1. Excavation proceeds horizontally into the deposit.
2. Visual impact of exposed banks prominent but limited by pit slopes and relationship to surrounding land forms.
3. Open end of pit requires screening.
4. Limited amount of unmineable material available.

#### Flat Terrain Deposit

1. Excavation proceeds down into the deposit below surrounding grade.
2. Bodies of water result from excavation.
3. Processing plant and stockpiles present major visual impact. Operations can be viewed from four sides.
4. Large amounts of land forming material are available.

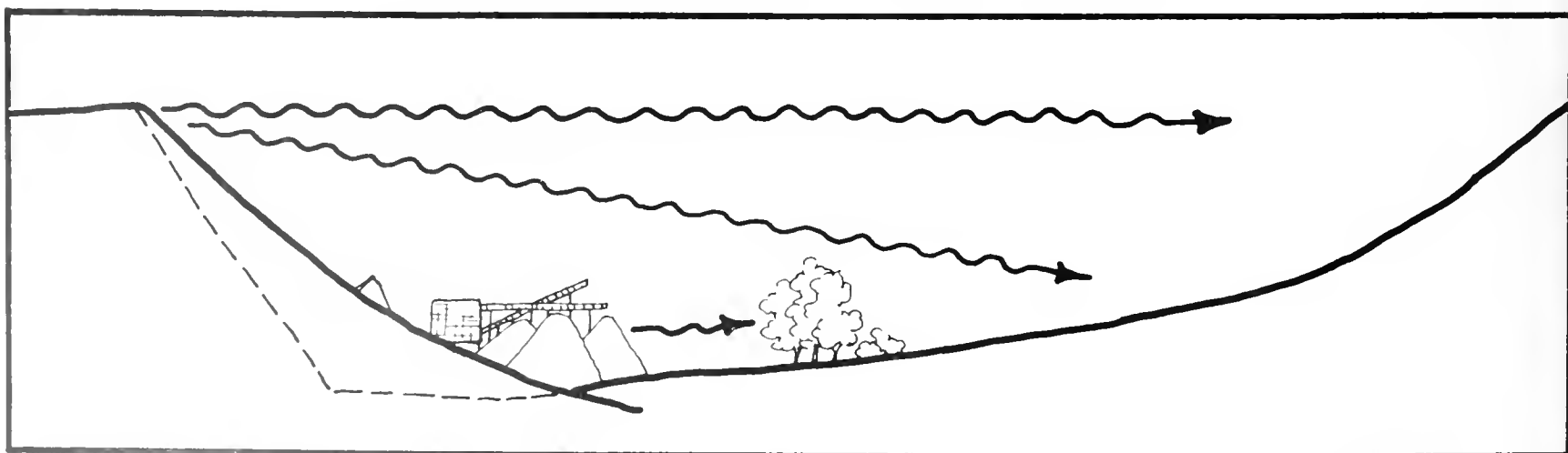
#### Testing

Information generally limited for planning purposes.

### Site Location

The major site location determinant is the economic limitation of transportation. The cost of transportation orients excavation activity in a zone surrounding metropolitan areas that is currently rural but rapidly changing to a suburban environment (Fig. 19 and 45). As a result many excavations occur where land is or is becoming heavily populated and highly developed (Fig. 2), where an increasing number of land uses are competing for the land, where land values are high and rising, and where land use controls are more stringent and complex.

**Fig. 43 (2) – Dominance of Pit Slopes – Hillside Pit**





The environment surrounding most operations offers several advantages for developing a sand and gravel site. Land values and land use demands are the most significant. Because of the demand, a host of development opportunities are often present. Because of the land value, development of these sites becomes feasible. However, sites in remote areas where land values are low can also contain valuable potentials. For example, sites consisting of large bodies of water attract recreational and residential uses, especially in areas where natural bodies of water are limited.

The demand for land, its value, and the variety of potential land uses are variables that are directly related to the location of an operation. In a suburban environment, a greater variety of use potentials exists. Industrial sites, recreation areas, and residential lots among a variety of other uses can be considered.

In addition to transportation, zoning and surface development affect the location of a sand and gravel site. Generally these two factors force the excavation of sand and gravel from the populated areas while transportation draws it toward the suburban area.

Check list of planning considerations:

1. Transportation orients the operations near urban areas.
2. The operations are competing with the forces of an urban environment including zoning, land competition, surface development, and public opinion.
3. As a result of the general location pattern the opportunities and benefits for land development are significant.

## Equipment and Operations

While the deposit furnishes the material, and the pit provides the foundation for development, the equipment used in the sand and gravel industry includes the tools needed in the execution of the land development program. Many types of earth moving equipment are available for creating and molding the designated land forms. It becomes the objective of the planning process to deploy this machinery in such a manner as to accomplish the combined functions of producing commercial sand and gravel and of creating desirable land areas simultaneously.

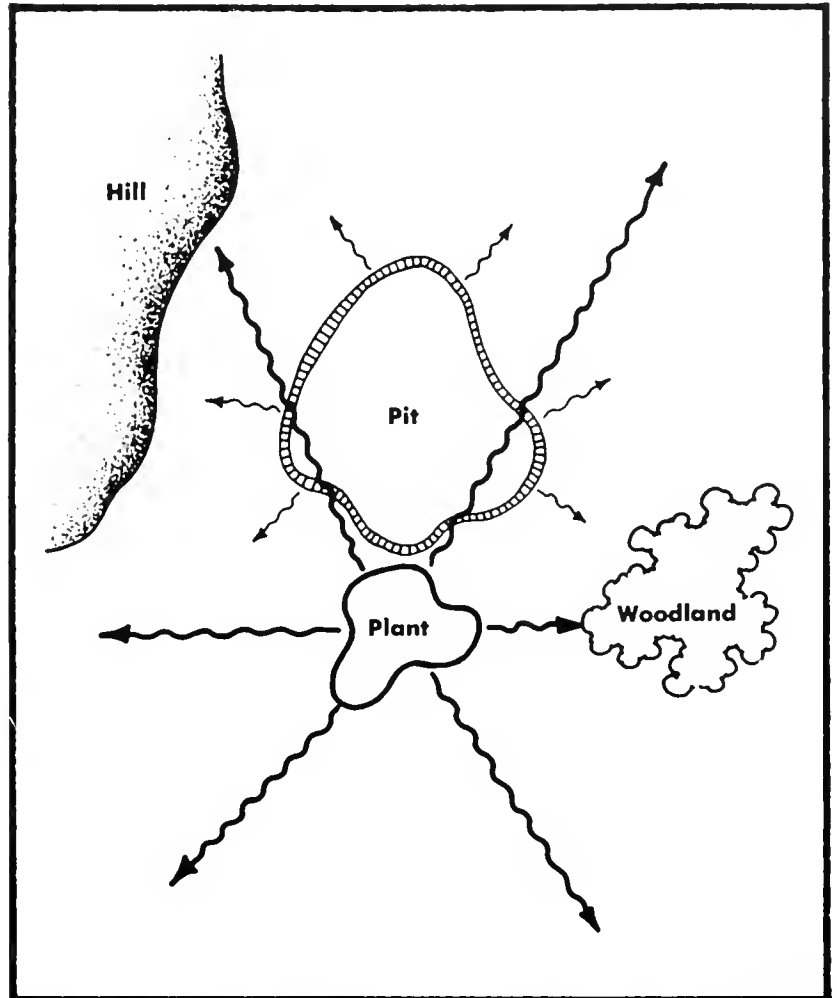
For planning and development purposes there are two basic types of equipment used in the excavation process. They are the excavating equipment such as the dredge and dragline, and the transporting equipment such as the belt conveyors and trucks. Included in the excavating category are the vehicles used to excavate and haul overburden.

This equipment operates in defined lineal, radial, and fan-shaped patterns and undiscernible, erratic patterns according to their capabilities. They create the general pit characteristics.

Manipulation of this equipment is the key to progressive land development. The land forming process must be inte-

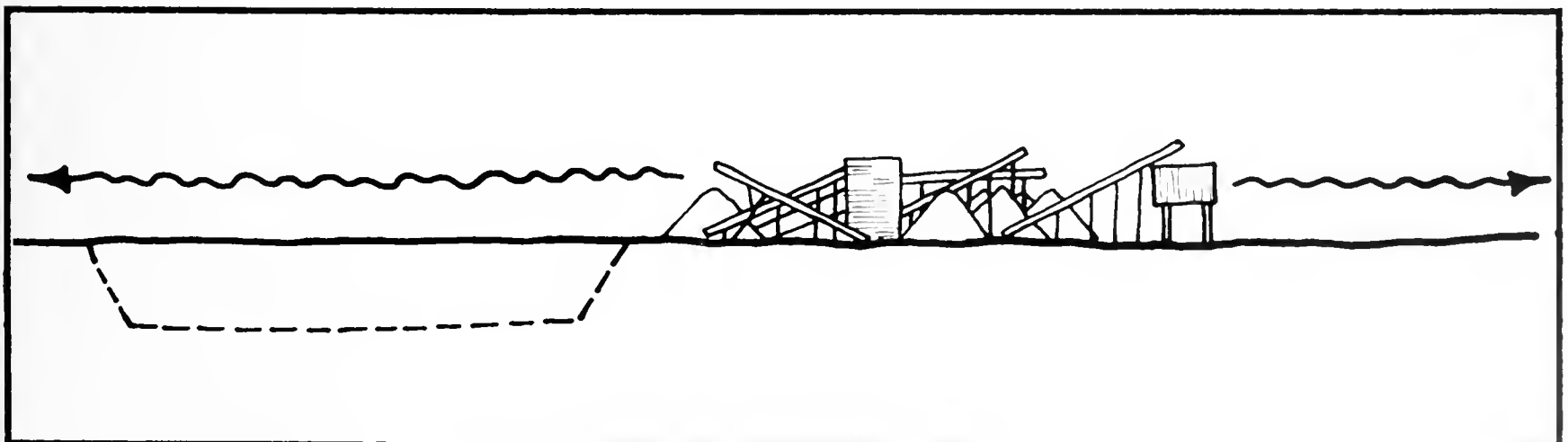
grated with the excavation process, taking into account the influences of the equipment capabilities, plant location, deposit structure, and the surrounding environment. The land use potential can best be developed by directing the excavation equipment into patterns that will facilitate progressive development of proposed land and water areas as well as efficiently process the natural resource, and allow minimum hauling and grading of the land forming material.

Transporting machinery operates in the wake of the excavation process or, in the case of moving overburden, precedes the excavation process. It is an objective of the planning process to minimize the hauling distance. However, there will be occasions when additional benefits can be derived by moving more material greater distances.



**Fig. 44 (1) – Elements Influencing the Visual Impact of Operations in Flat Terrain**

**Fig. 44 (2) – Equipment Dominance in Flat Terrain**





**Fig. 45 (1) – Site in the Path of Urban Development**

Except for the desander, the processing machinery has little bearing on actual development of the sand and gravel pit. A desander, however, especially a semi-portable one that is contiguous to the excavation area, can be a significant asset to land development. By manipulating the pipeline through which the excess sand is pumped and by strategically locating the two or three movements of the desander, on a large site, (the portable desander always operates in conjunction with a dredge and within a distance of 1200 feet from the dredge) considerable potential for creating functional and aesthetic land areas is available. Generally it is most desirable to deposit excess sand as near to the desander as possible.

### **Pit Characteristics**

Three prominent land form types are created by the excavation process. They include the steep pit slopes, overburden piles, and fan shaped waste sand deposits.

In terms of planning, the height of the pit bank presents the most significant problem. Erosion, access, and safety factors must be considered. But these same slopes may also be an asset as enframing and screening elements.

Overburden deposits are very significant land forms in many pits. They often occur in a series of windrows that either flow together or are separated by distances up to 200 feet, depending upon the amount of material and type of excavating equipment used to redeposit it (Fig. 29). Many of these windrowed deposits will require extensive regrading to obtain a mowable slope.

Waste sand formations are usually, but not always, associated with water areas. They are often developed into excellent

beaches, and can contain many types of uses when covered with overburden.

Another feature resulting from the excavation process is the body of water. Although large navigable water areas are often created, many of the sites contain small, shallow, and stagnant pools. Occasionally a large body of water is only several feet deep and contains many remnants of exposed land. Water fluctuations often expose additional land forms.

In developing a water area, it is important to take into consideration ground water elevation, deposit depths, underground water movement, and the expected water area.

Although the processing plant is not an asset in improving the use potential, it requires considerable attention in the planning program. Its character and location warrant consideration.

The plant area is of an industrial character that is often more incongruous with the surrounding landscape, and stimulates more resentment toward the industry than the actual excavation or pit area. These plants are generally located above the pit on unexcavated ground with their heavy equipment and huge stockpiles rising above the terrain; and for access purposes, near public roads in full view of passing motorists. Three of the most frequently objected to nuisances stem from this area. They include truck traffic, noise, and visual offenses.

Check list of planning considerations:

1. Manipulate the excavation equipment within the scope of its operating patterns.
2. Minimize hauling distance of land forming material.
3. Land forming potential associated with the desander.
4. Consider the location, character, and visual impact of the processing plant.



**Fig. 45 (2) – Site in the Path of Urban Development**

## Current Rehabilitation Practices

There is little doubt that rehabilitation of depleted sand and gravel deposits offers considerable economic advantage in the resale of the property. Several examples have been cited concerning the increased value of rehabilitated sites over original land values. But the advantages of land rehabilitation, and of conscious land use extend beyond direct financial gains.

It applies to the community's attitude toward the industry. It is a tool in public relations work which may eventually influence the opinions of local citizens and officials and their decisions concerning future requests for permission to excavate. A conscious rehabilitation program can open lands for mineral extraction previously considered inaccessible. In the research questionnaire, 40 percent of the companies that maintained a rehabilitation program reported that their activity favorably influenced zoning decisions.

Most of the current rehabilitation projects have developed in compliance with minimum zoning regulations or because of a special demand arising due to the presence of certain pit features. Little forethought was given to the type of land use or to the development of the most functional land areas. In almost every rehabilitation site reviewed, evidence of unusable areas and features detrimental to the desired character of the use were noted. Remnants of waste sand and overburden, shallow water, small stagnant pools of water, and eroding banks deteri-

orated the development. It is not that the rehabilitation efforts were unsuccessful. It is just that the potential of the sites was not fully developed. Many of the undesirable conditions could have been avoided. Pre-arranged placement of the waste material for the benefit of the rehabilitation project could have created additional and more desirable land and water areas in most of the sites.

One of the most serious limitations in the development of usable land areas in sand and gravel excavations is the separation of rehabilitation and processing operations. Even when progressive rehabilitation is carried out, the two types of activities are not coordinated. What the excavation does to the land, rehabilitation must undo. This condition results in indiscriminate placement of waste material, uncoordinated patterns of excavation, and the creation of troublesome obstacles, such as high, steep banks, and large shallow bodies of water.

Since land development is not their reason for being in business, few sand and gravel producers realize the potential contained within their sites. Therefore, most attempts at rehabilitation are limited to a reduction of the objectionable characteristics created by the excavation.

Check list of planning considerations:

1. Coordinate excavation and development functions.
2. Reduce creation of derelict land areas.
3. Consider impact of operations on surrounding land area.

# Procedures and Recommendations

## Procedures

A planned sand and gravel site development program is primarily concerned with progressively developing the highest and best use concurrently with the extractive operation. The plan takes advantage of site and operation characteristics and directs the excavation process into a dual role of excavating material and creating pre-conceived land forms. In addition, the planned approach is concerned with the impact that the site and operation has on adjacent lands. In order to accomplish these objectives, an analysis of the influencing factors should be completed as soon as possible to determine the most appropriate land use, to determine the proper action for accomplishing this land use, and to determine methods of reducing the normal conflicts associated with the operations.

Many operations contain three conditions that contribute to the land use potential of a sand and gravel site.

1. There is a considerable amount of material in excess of the commercial sand and gravel that is suitable land forming material, and that must be handled to obtain the desired sand and gravel.
2. The industry utilizes heavy excavating and transporting equipment that can be used in creating land forms.
3. Sand and gravel operations are often located in an environment where the land value is high and where numerous opportunities for developing a land use exist.

A systematic approach in the development of these conditions will reveal the greatest land use potentials. The following pages contain recommendations and considerations in developing the ultimate use of a sand and gravel site.

## Planning and Design Sequence

A planned excavation and development process of a sand and gravel site evolves from three basic planning phases.

1. Collecting and recording information.
2. Analysis—to determine pertinent and influential factors.
3. Formulation of the development plan and associated detailed plans.

The first step in developing a plan is to gather information pertinent to the development of a land use. Information concerning the (1) site, (2) deposit, (3) equipment and operational procedures, and (4) environment must be obtained. The plan proposals will reflect the degree of detail and accuracy of this survey information.

Following are lists of data of prime concern in planning. Much of the required information can be obtained from various maps in local planning offices, from U.S.G.S. maps, and from soil survey maps. However, data such as ground water, deposit structure and operational characteristics are not normally available but must be obtained to produce a functional plan.

1. The site
  - a. Property line survey.
  - b. Easements and rights-of-way.
  - c. Location of roads—indicate type of surface.
  - d. Contour maps—2 or 5 foot contour interval (2 foot interval preferred).
  - e. Aerial photograph (400' scale) if available.
  - f. Location of wooded areas—type of trees.

- g. Existing ground cover.
- h. Relationship of the site to surrounding terrain.
- i. Areas of most probable visual conflict.
- j. Views into the site.
- k. Special surface features such as streams, rock outcroppings, etc.

### 2. The Deposit\*

- a. Depth of topsoil and subsoil (overburden).
- b. Topsoil and subsoil characteristics.
- c. Deposit depth and outline.
- d. Composition of sand and gravel.
- e. Percentage of waste sand.
- f. Depth, outline, and type of unmineable material.
- g. Ground water elevation.
- h. Ground water flow.

### 3. Equipment and operational procedures.

- a. Type of excavating equipment.
- b. Anticipated general excavation patterns.
- c. Type of transporting equipment.
- d. Processing plant layout (diagrammatic).
- e. Area required for processing plant, including stockpiles.
- f. Location of settling ponds.

### 4. Environment

- a. Zoning and land use maps.
- b. Existing land use—adjacent to and in the general area of the site.
- c. Development trends (patterns of expansion).
- d. Access and transportation arteries.

The second step is the analysis of the collected data to determine the potentials of the site and to determine factors such as views and plant locations, that will require solutions in the planning proposals.

The following information is of immediate concern and is partially illustrated in Figs. 46 and 49.

1. Determine the volume of material unsuitable for processing.
2. Define the areas in which these volumes are located.
3. Outline unmineable deposits.
4. Outline shallow and segmented areas, in the case of wet pits, and packed, irregular pit surfaces in the dry pit.

Analysis of this information should be followed by a review of the equipment and operational factors to determine their patterns and capabilities as influenced by the site. (Fig. 47).

This step is followed by a review of equipment and operational factors to determine their patterns and capabilities as influenced by the site. These patterns will have some effect on the selection of a land use, especially in relation to creating land forms, but they will be altered somewhat, in the light of environmental factors, such as views, and in accord with the designated land areas.

Unless the use had been previously selected, the next step is to study the environmental conditions, analyze these conditions in relation to the site and operational factors and select an appropriate use. A development plan designating the land use and land forms is then drafted. From this plan, detailed operational plans will be formulated, including excavation plans, stockpile plans, screening plans, grading plans, and progressive development plans.

\*Number and types of test borings required to define the deposit character will depend upon the variation within the deposit. Current test of one boring per five or ten acres generally provides inadequate information.



Most of the detailed plans will be finalized during and after the excavation to adjust alignments, land forms, and elevations, to fit in with unexpected deposit variations. In addition, due to the long life of many deposits, environmental changes may require alteration of the detailed plans. In other words, the development plan and related operational plans are not absolute in the sense that final elevations shall be within "x" number of inches or that the land forms shall be the exact area and form proposed.

There are several immediate advantages in establishing a plan in advance of any excavation activities. One is that plant material screens can be planted immediately so that in the time lapse between planting and excavation the plant materials will begin to develop into adequate screens. The time lapse may be from one to ten years. These planting screens can be designed in such a manner as to offer aesthetic qualities to the proposed land areas as well.

Another advantage of early planning is in considering acquisition of additional land to facilitate the ultimate development of the site and to provide buffers between the operations and adjacent land uses. There will be situations when the distance between the edge of excavation and the property line is too narrow for any particular use. There will also be occasions when additional land is needed in order to develop a desired use such as a golf course.

The pros and cons of purchasing additional land should be studied in relation to the potential benefits derived from the proposed land use. This proposal should be reviewed early in the planning stages so that if the land is purchased, it can be included in the progressive development proposal.

Still another advantage of early planning is that the plant area can be sited to take advantage of any natural screening with due consideration for access and relationship to pit area, and that any necessary screening of the plant area can be established early.

## Recommendations

Following are suggested procedures for organizing and constructing a development program, taking into account the physical appearance of the total site during the operations.

1. Determine location of processing plant area and type of screening essential to reduce the inherent conflicts. Landscape the entrance and area adjacent to the plant. Maintain buildings and equipment and eliminate weed covered waste heaps and accumulation of discarded parts and equipment.
2. Construct screens of either plant materials or overburden piles where it has been determined that visual or other conflicts such as dust and noise may occur. (This should be completed as soon as possible after land is purchased.) Slope overburden screens and seed to grass or other suitable ground cover. The designation of overburden screens should

correlate with the proposed land forms, so that when the screen has served its purpose it can be converted into the determined land forms with minimum grading.

3. Determine the pattern of excavation that will implement the development of the proposed land forms. Excavate in proposed land areas first to permit placement of waste sand and overburden. If there is a choice and an opportunity to excavate on either side of a hill or wooded area, consider initiating the excavation on the side offering the most screening.
4. Stockpile the overburden material in areas designated for future land forms or in excavated areas where the material will be spread over the pit floor. Plan the stockpiling procedure to minimize handling. The objective in handling this material is to (1) excavate, (2) stockpile, (3) grade to the desired land forms. Stockpile material where waste sand is deposited. Spread the material over the land form when the operation is complete. Seed stockpiles if they are to remain any length of time.
5. Progressively develop excavated areas by grading the land forms and stockpiles to desired grades. Seed and plant developed land forms immediately after grading is completed or within appropriate planting seasons.
6. When shallow water or obstacles such as clay veins or rock outcroppings are encountered, consider their impact on the character of the proposed development. Either take advantage of them by creating additional land area or more interesting land forms or deepen the water area and remove the obstacle.
7. Remove all equipment associated with the industry as soon as excavation is terminated. Do not permit the accumulation of debris and abandoned equipment. Reduce remaining waste heaps to acceptable land forms and seed.

In addition, when special situations exist and an obvious benefit can be attained, the producer should consider:

1. Acquiring land in addition to the sand and gravel property to:
  - a. Facilitate development of the proposed use.
  - b. Provide a buffer between the operations and surrounding land uses.
2. Preserving parts of the sand and gravel bearing land for the proposed development when it is or contains features more valuable than the underlying sand and gravel.

When use of a site is determined before excavation begins and when the excavation process is organized to develop the determined use, then the waste heaps, the shallow, stagnant, and small bodies of water, the unusable remnants of land, and the eroding, barren slopes normally associated with a sand and gravel pit can be eliminated. The benefits are more than just an economic return through increased land values. They include the intangible benefits of improved public relations and good will.



# Case Studies

Two case studies are presented to illustrate the procedures for developing the use potential of a sand and gravel deposit. The Lincoln Lakes site, operated by the Lincoln Sand and Gravel Company of Lincoln, Illinois was designated as the representative case study for this research project. Sansabar Estates

is an independent study of the combined efforts of graduate landscape architecture students, Mr. Robert Belden, and the author, in fulfilling requirements of a graduate design course. It is an unexcavated site owned by American Aggregates Corporation of Greenville, Ohio.

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## LINCOLN LAKES

### *Location:*

Lincoln Lakes is located in Central Illinois one mile south of Lincoln, population 17,000, and two miles distant from U. S. highway 66. The city is a geographic hub in a ring of four major communities radiating 30-50 miles from its center: Springfield, population 85,000 (State Capitol), Decatur, population 80,000, Peoria, population 110,000, and Bloomington, population 36,000.

The study area is adjacent to the Lincoln Lakes residential and recreation site illustrated in NSGA's Rehabilitation "Case Histories" brochure. It is an extension of the operation that created the residential area.

### *Site Characteristics:*

The site is 480 acres of flat terrain situated in a flood plain that borders the city of Lincoln. Two streams affect the site. One flows north along the west property line. The second stream is channeled across the property, currently separating the excavated and unexcavated portions. During the spring months these streams usually overflow their banks and flood a significant portion of the surrounding area to two and three foot depths.

Wet land, associated trees, including willows and poplars, line the stream channels and are growing along cut banks and on waste heaps. Vegetative regrowth in disturbed areas appears to be rapid, especially where water is immediately accessible. Also, the old overburden heaps seem to generate rapid regrowth.

The property is situated in a rural agricultural environment. The Lincoln Lakes residential area is adjacent to the site but the remaining area contains large farms. The area between the property and the city limits has little to no surface development.

Access to the property is by a private paved road. In addition a rail spur connects the plant area with the main line.

Currently the site is divided into two areas consisting of the excavated lands and the unexcavated lands. 210 of the 480 acres are either excavated or will remain unexcavated. The excavated portion contains 95 acres of water with depths to 50 feet. The water elevation is normally eight to ten feet below the surrounding terrain, but fluctuates from flood stage to about fourteen feet below the terrain, between the spring and fall seasons.

Views into the site are not prominent enough to warrant planning considerations. The lay of the land is such that the pit area is not seen until the cut bank is approached. Like many flat terrain operations the plant and associated forms can be viewed from a distance. However its visual impact on the surrounding area is negligible. Vast expanses of agricultural lands reduce any conflicts that may exist. In addition a major portion of the

site is screened from the south-southeast by the tree line along the channeled stream, and from the west and northwest by the heavily wooded area along the western property line.

### *Controls:*

Although the City of Lincoln has adopted a zoning ordinance, no land use controls regulate the site and operations.

### *Deposit Characteristics:*

The deposit contains between 30 to 55 feet of material. This material is about 40 percent sand with the amount of sand increasing to 70 percent toward the southern property line.

Approximately 1.5 million cubic yards of overburden cover the deposit. This material is from four to eight feet deep.

Little unmineable material is present in the deposit. However, an area of approximately ten acres, consisting of clay and sand, extends in from the southern property line. In addition, the original course of the stream that crosses the site, meandered south of the current stream. This old stream bed was filled to grade, and will be avoided in the excavation process.

The deposit information was obtained from resistivity tests conducted one per ten acres. Information concerning the depth of overburden, composition of sand and gravel, and depth of deposit was recorded.

### *Operations:*

Basically, the operation involves excavation of material by a dredge, conveyance from the dredge to a surge pile by pipeline, conveyance from the surge pile to the processing plant by belt conveyors, processing and stockpiling, and transporting the product off the site by rail and truck.

The dredge operates in fan-shaped patterns away from the surge pile. It is expected that the dredge will operate 2500 feet from this surge pile and that the material will be piped this distance, with the assistance of a series of booster pumps.

The processing plant, including loading facilities and stockpiles, covers about 15 acres. Rail and truck access is combined on the north side of the plant. No excess sand is available for land forms; however, slightly less than five percent of the excavated material is sluiced out with the water discharged from the processing plant, in the form of fine sand. Over the years of operation this material will enlarge the land area around the processing plant.

Stripping and stockpiling overburden is contracted to a local construction firm. An area the size of the anticipated yearly excavation is stripped each fall. One of the current stockpiling objectives is to create dikes along the western property line and on the old stream bed for flood control. This objective is incorporated into the stockpiling plan.

#### *Proposals:*

The proposed use is a privately operated recreation complex that includes boating, picnicking, camping, swimming, and fishing facilities. It is based on the idea, and the fact, that people will pay for leisure activities if the facilities are functionally and aesthetically designed and adequately maintained.

The use was selected primarily on the basis of site conditions. Flooding is a constant threat; consequently a host of other land uses could not be applied. The fact that a potentially large lake existed and that there will be sizeable land areas for various activities, assisted the selection of the land use. Due to time limitations no market analysis was conducted.

The objectives of this plan were:

1. To utilize unexcavated land forms within and on the perimeter of the deposit and to expand and improve these land areas with the more than 1.5 million cubic yards of overburden.
2. To enlarge the water areas to meet the requirements of the proposed land use.
3. To keep the handling of the overburden to a minimum by correlating quantities and locations of stockpiles with proposed land area.
4. To progressively develop the areas (a) for early use, and (b) to allow the area to naturally develop into a mature landscape that is desirable in such activities as camping and picnicking.

Following are the proposals for creating the designed land forms:

1. Divert east-west stream into excavated lake and open the land channelling the stream and the land form covering the old stream bed to enlarge the lake for speed boating and water skiing activities.
2. Keep smaller lake enclosed for slow boating and fishing activities, but construct culvert in "fishing bank" (dike) for water movement. Create outlet as indicated on the master plan.
3. Fill in channel for additional useable land.
4. Take advantage of the shallow area along the west shore line and of the small narrow land forms of the old stream bed and existing channel, in creating additional land with the overburden.
5. Tie in grading and planting with the stripping and stockpiling operations conducted in the fall.

#### *The Plan:*

The first two sheets of the plan, Site Analysis, and Operation Analysis, illustrate the various characteristics that will influence the proposals and subsequent development. The last three sheets, Master Plan, Stockpile Plan, and Development Program, display the proposals and procedures for development.

#### *Site Analysis:*

This drawing essentially contains two sets of site data. They include: the elements resulting from the excavation process, and

the conditions that exist in the undisturbed deposit.

Information in the excavation portion identifies the land and water areas, and special surface features such as slopes and wooded areas, that affect the type of use and shape of the land form proposed.

The unexcavated area contains information about the deposit structure. It displays the surface contour, by a heavy solid line; the contour at the base of the overburden or top of the deposit, by the parallel dashed lines; and the contour of the deposit base by the dashed lines. In addition, the land areas, unsuitable for processing and the edge of excavation, are outlined.

This sheet of information is the base of the land proposals. The forms, the areas, the types of uses, and the development procedures are directly related to these site features.

#### *Operation Analysis:*

The operation analysis drawing is a schematic presentation of the methods of excavation and transportation, and the location of facilities. In this particular situation the current method of excavation will require little to no alterations. The development proposals operate within the framework of this displayed system.

#### *Master Plan:*

This drawing illustrates the proposed land forms, land uses and some of the basic surface features. The information on this sheet which has been correlated with the site analysis information, is detailed into the various development plans, of which only the stockpile plan and development program are included in this report.

#### *Stockpile Plan:*

Location of stockpiles and proposed land forms are indicated in this plan. In addition, areas containing the overburden needed to create the land forms, and the general direction that the material is to be handled is designated.

The areas containing specified amounts of overburden were laid out to correlate with the location of the land forms and with the volumes required to create the land forms. The objective of this procedure is to strip the proper amount of overburden from the areas closest to the proposed land forms.

Topsoil will not be separated from the overburden. Three factors contribute to this decision. First, information about the soils was not available. Second, after reviewing the Lincoln Lakes area, it is apparent that natural vegetative regrowth is rapid and healthy on old overburden piles. Third, with consideration for the second factor, the time element between a progressive development program and the termination of the operations would permit satisfactory growth of ground covers and upright plants.

#### *Development Program:*

This sheet identifies the areas to be developed according to a time schedule, and states the type of development activities that should take place during the course of the sand and gravel operations. The development program ties in with the current excavation pattern without affecting its direction of operation.



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The following five pages contain plan and elevation drawings of the Lincoln Lakes Project.

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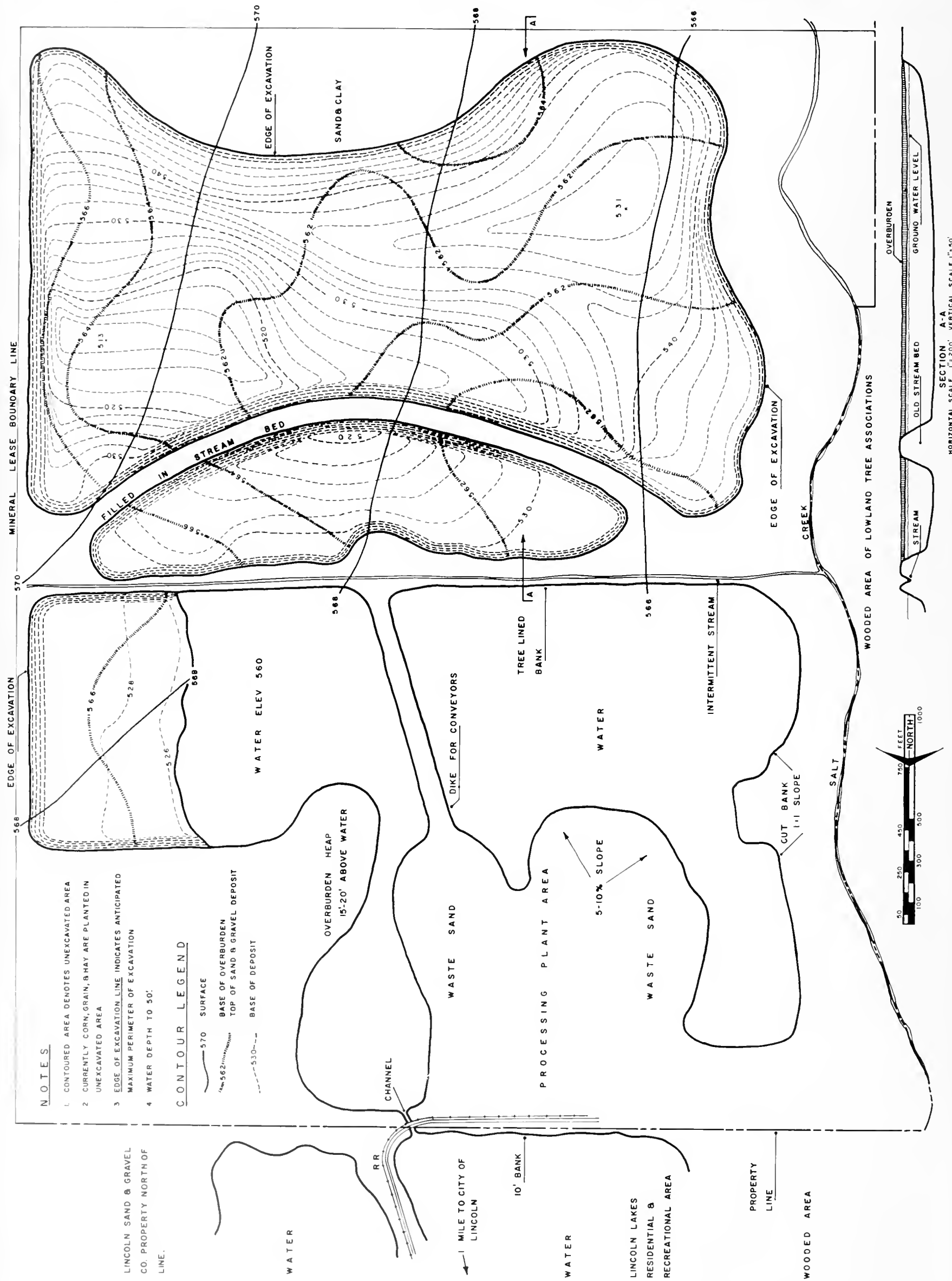
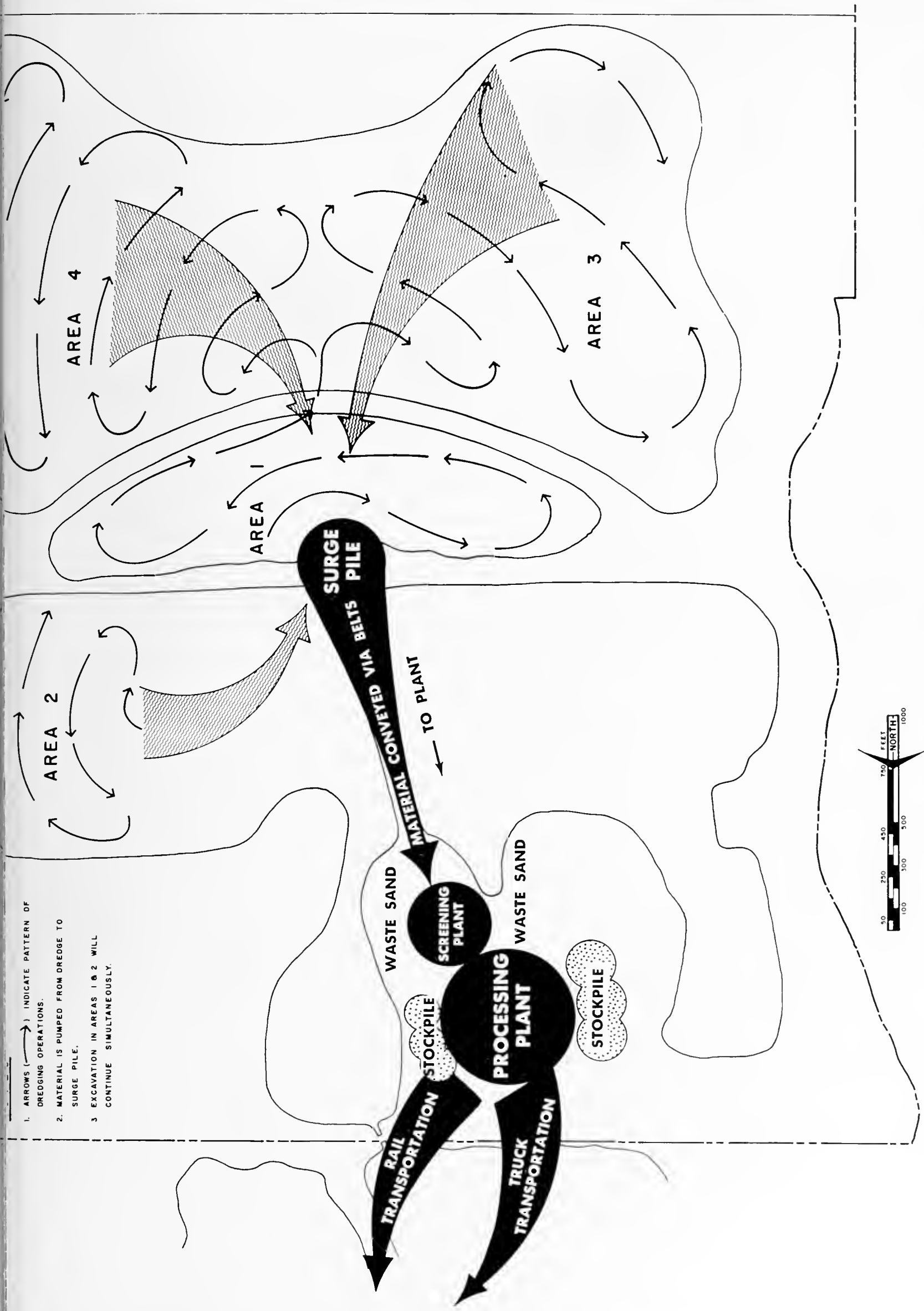


Fig. 46

# SITE ANALYSIS

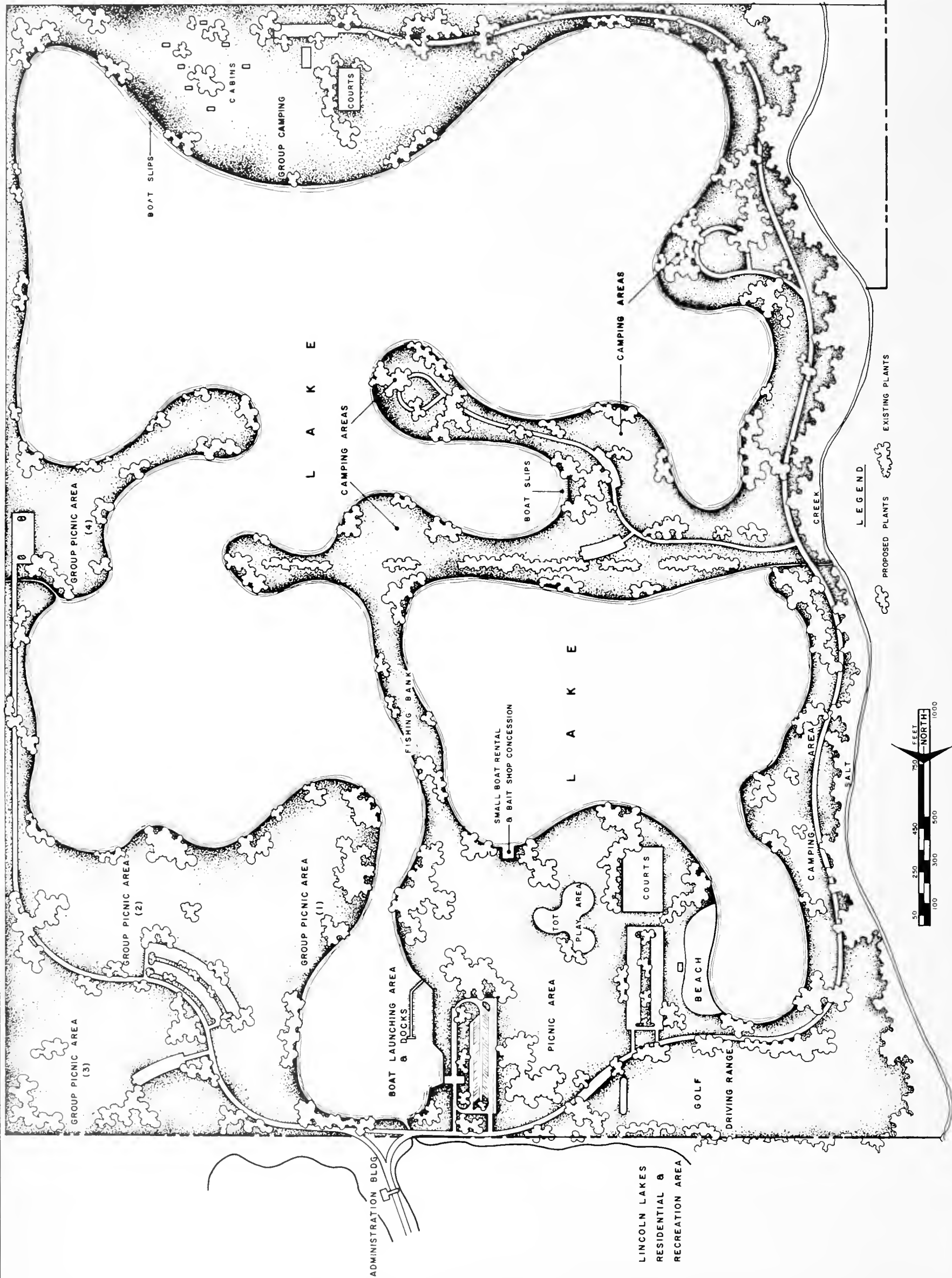
## LINCOLN LAKES





1. ARROWS ( ) INDICATE PATTERN OF DREDGING OPERATIONS.
2. MATERIAL IS PUMPED FROM DREDGE TO SURGE PILE.
3. EXCAVATION IN AREAS 1 & 2 WILL CONTINUE SIMULTANEOUSLY.

Fig. 47



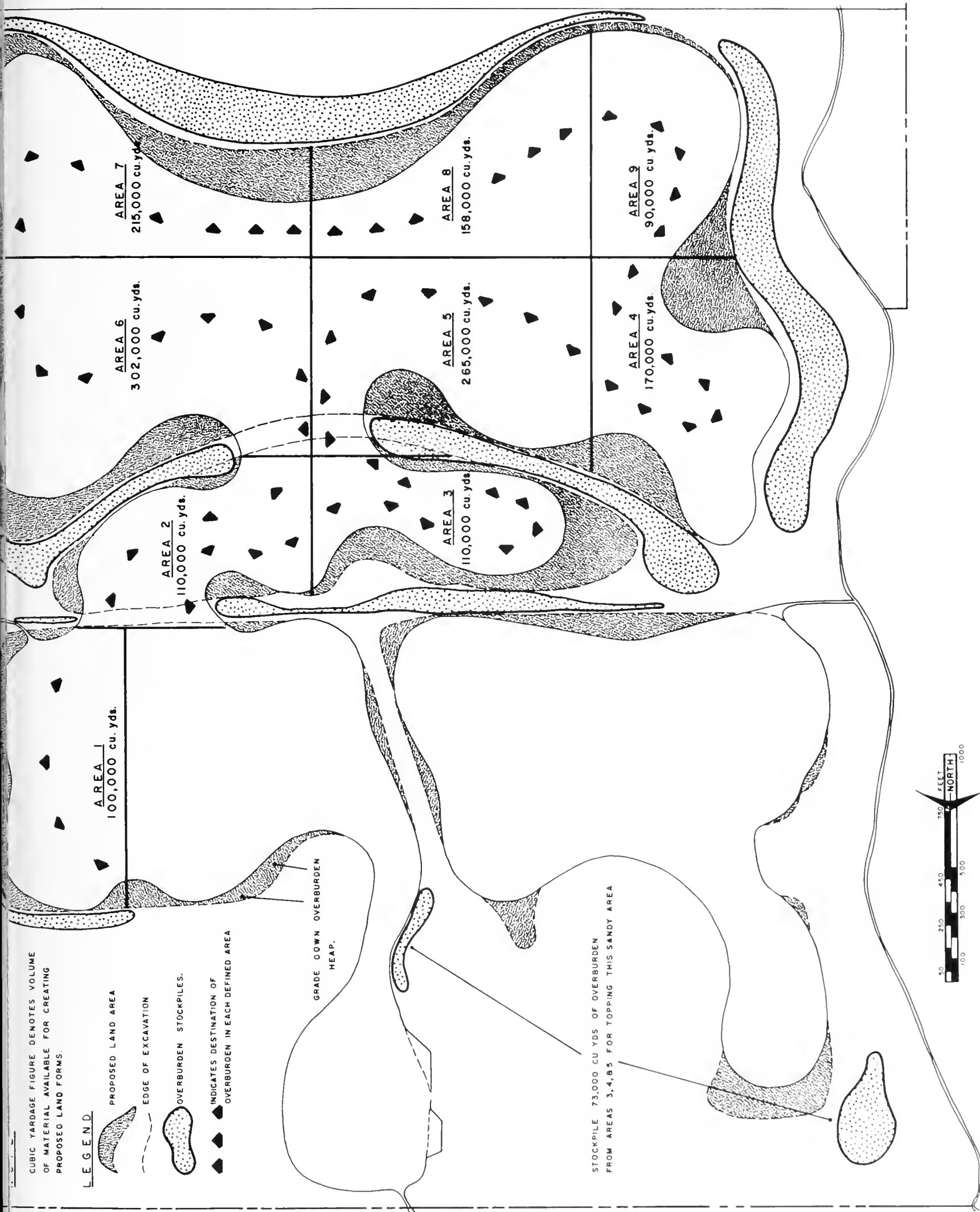


Fig. 49

# STOCKPILE PLAN

LINCOLN LAKES

## STAGE I

GRADE, SEED, PLANT TREES, AND LAY-  
OUT PROPOSED ROADS AND FACILITIES  
WHILE EXCAVATION IS CONTINUING IN  
EXCAVATION AREAS 1 & 2 (SHEET 2)

## STAGE III

GRADE, SEED, AND PLANT TREES DURING  
AND AFTER EXCAVATION IN EXCAVATION  
AREA 4 (SHEET 2) BEGIN CONSTRUCTION  
OF PROPOSED ROADS AND FACILITIES  
ON TOTAL SITE.

## STAGE III

(SEE STAGE III UPPER RIGHT) REMOVE  
DEBRIS AND EQUIPMENT BEFORE AND  
UPON TERMINATION OF OPERATION.  
SPREAD STOCKPILED OVERBURDEN  
OVER SAND AREA.

## STAGE II

GRADE, SEED, PLANT TREES, AND LAY-  
OUT PROPOSED ROADS AND FACILITIES  
WHILE EXCAVATION IS CONTINUING IN  
EXCAVATION AREAS 1, 3, & 4 (SHEET 2)

## STAGE I





# SANSABAR ESTATES

The planning procedure for Sansabar Estates, although basically similar to the Lincoln Lakes study, was somewhat more complex. The plan had to take into account unobstructed views into the property, site and deposit variations, the use of two excavating units, and more severe slope conditions.

The property is a southerly sloping 312 acre parcel, situated on the banks of a flood plain, six miles north of Indianapolis, Indiana. It is surrounded on three sides by public roads. Passing motorists have unobstructed views into the site along half the property lines. About half the site is screened by woodlands containing oak, maple, beech, and elm trees.

A 100 foot wide gas line easement angles across the property dividing it into a north and south section.

The deposit, covered with two to seventeen feet of overburden, contains about 65 percent sand. Significant areas of clay are located in the northern section. Depths of sand and gravel range from 20 feet in the southern part to 35 feet in the center of the property.

The base of the deposit is generally parallel with the surface topography. In the northern section the deposit does not go below water line, while along the southern property line the water depth will be 25 feet.

A dredge and dragline operate concurrently in the excavation process. The dragline will excavate the deep deposit above water line and in areas beyond the reach of the dredge while the dredge will excavate material below water line within a 1200 foot radius of a desander. This desander will be situated in two locations on the site and will redeposit up to 40 percent of all excavated material in the form of waste sand. This excess sand can be pumped 1200 feet.

The material from the dragline operation and from the desander will be conveyed to the main processing plant, which is situated one half mile east of the site.

## Proposals

Sansabar Estates is a country estate, water oriented residential proposal. Liberal use of recreation lands and open spaces add to a rural character. One of the objectives of this project was to permit both Mr. Belden and the author to gain experi-

ence in the type of recreational layouts proposed. However, the main objective was to develop and organize procedures for utilizing the maximum land forming potentials of the equipment, excavation process, waste material, and deposit.

In addition to the detailed proposals prescribed for Lincoln Lakes, the following proposals are included in the Sansabar Estates plan.

1. Screen all areas of anticipated visual or operational conflicts with overburden stockpiles; grade, seed, and plant stockpiles to interesting and aesthetic appearance.
2. Correlate both excavating units with the development of the proposed land forms.
3. In addition to locating the desander with consideration for the operating limitations of the dredge, consider: (a) land forming potential of the sand, and (b) land forming potential of the sand in conjunction with the deposit features such as clay veins and shallow water areas.
4. Utilize topographic and vegetation features for screening the excavation process as long as possible.

One of the most significant conclusions from this plan is that not only is it possible to create a functional land area out of the excavation process but it is also possible to reduce any form of conflict associated with an operation. The overburden must be stockpiled. When a development program is followed, the material will be stockpiled in relation to the proposed land forms. If the plan is comprehensive, it will correlate the screening needs in the development proposal. And finally, to improve the total appearance of the site and operations, the producer should seed, plant and possibly create interestingly formed and well maintained earth mounds.

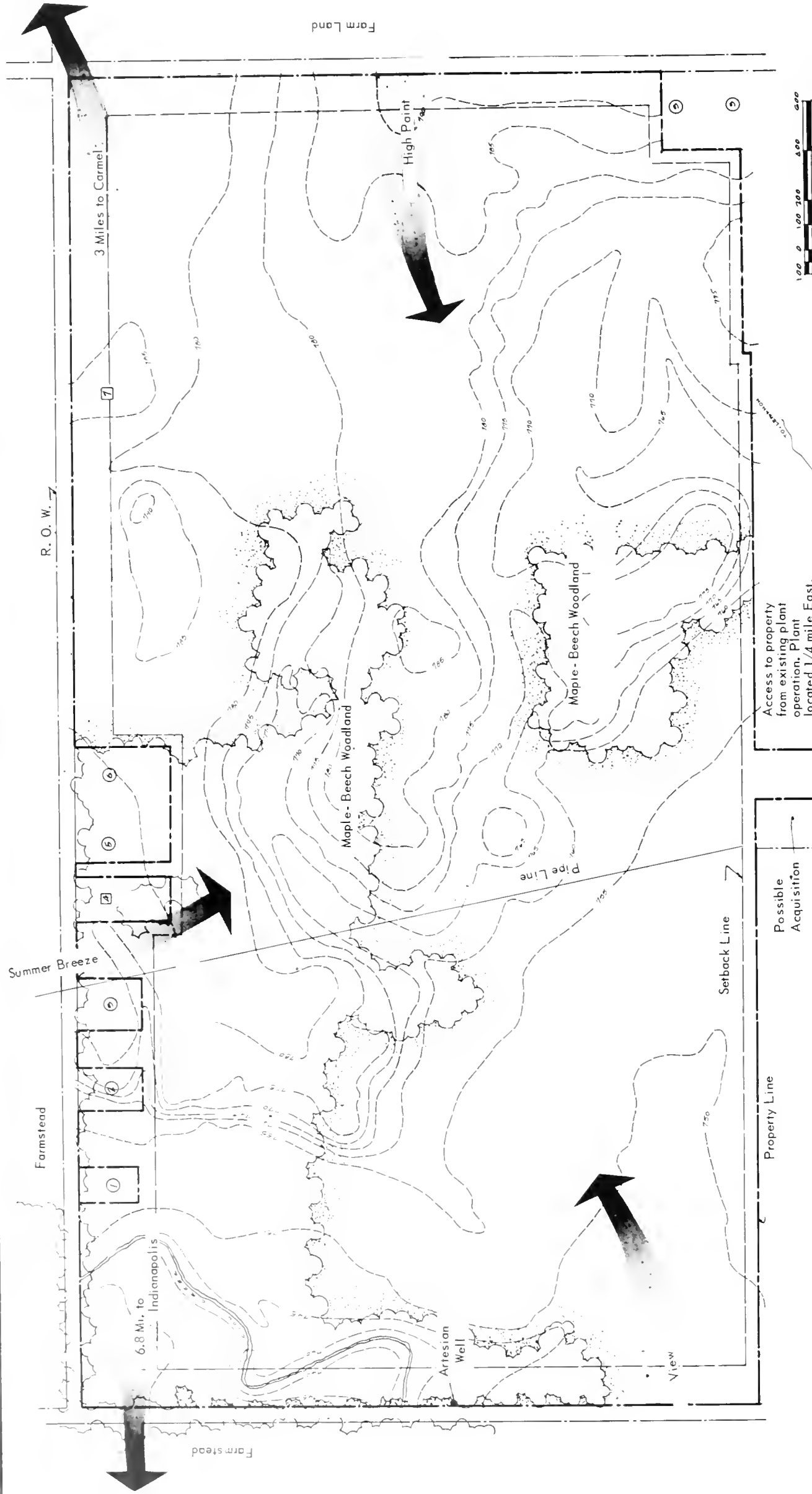
It should always be noted in the presentation of a set of plans for the ultimate use of a sand and gravel site that changes due to operational, deposit or environmental conditions might cause various degrees of changes on the plan. It may involve a change in grade or even an elimination of a proposed land area. This does not reduce the value of the plan, because a more functional adaptation can be formulated than if no plan existed.



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The following six pages contain plan and elevation drawings of the Sansabar Estates Project.

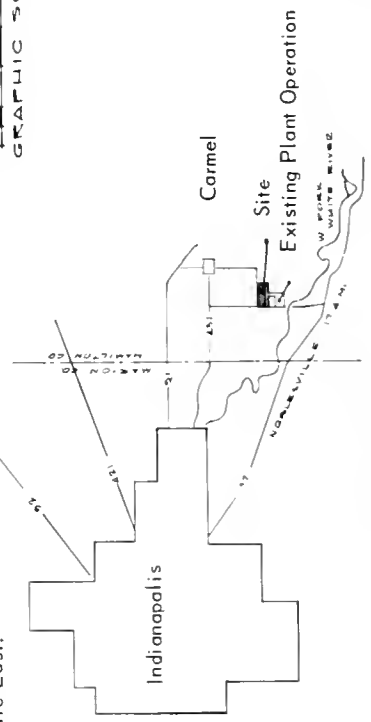
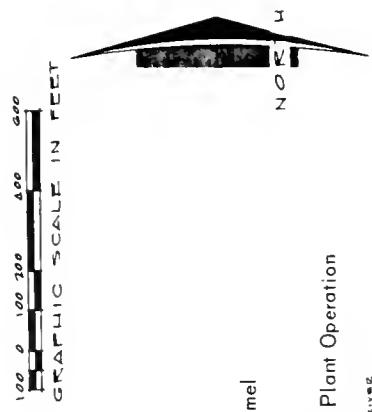
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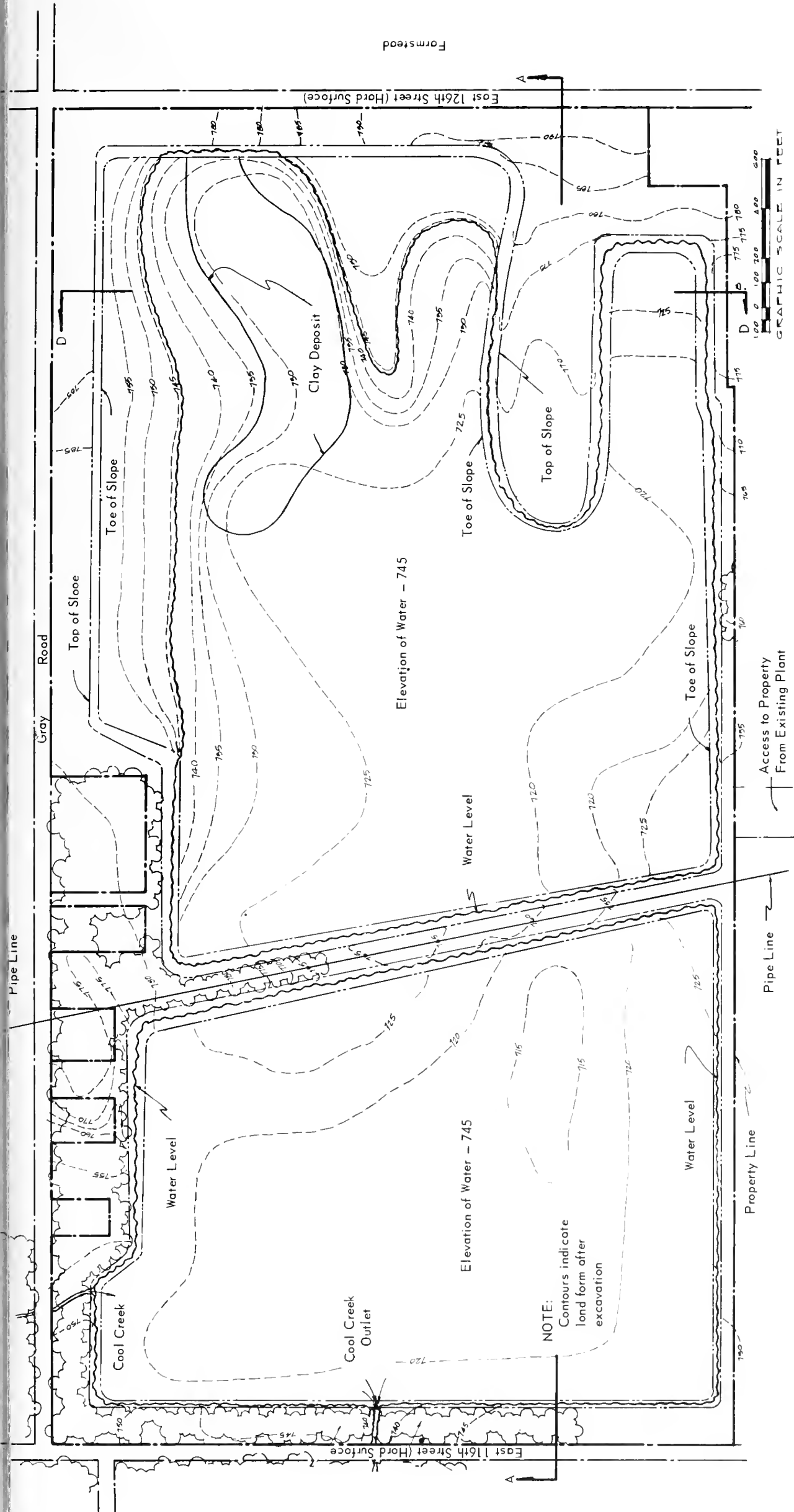
NOTES:  
 Zoning Regulations  
 Town of Carmel S-1 District  
 Single Family Residential Base  
 15,000 sq. ft. per family plus  
 15,000 sq. ft. per family without  
 sewer and water.  
 Residential development is extending  
 North from Indianapolis.  
 Total Land Area - 520 Acres

- LEGEND
1. Small Residence.
  2. Substantial Two-Story Residence, Possible Pre-War.
  3. New Ranch-style Home.
  4. Farmstead.
  5. New Ranch-style Home.
  6. Rustic Ranch-style Home.
  7. Farmstead - Old Buildings.

Access to property from existing plant operation, Plant located 1/4 mile East.



SITE LOCATION MAP  
 Scale 1" = 3 Mi.



SECTION A - A

Scale 1" = 200'

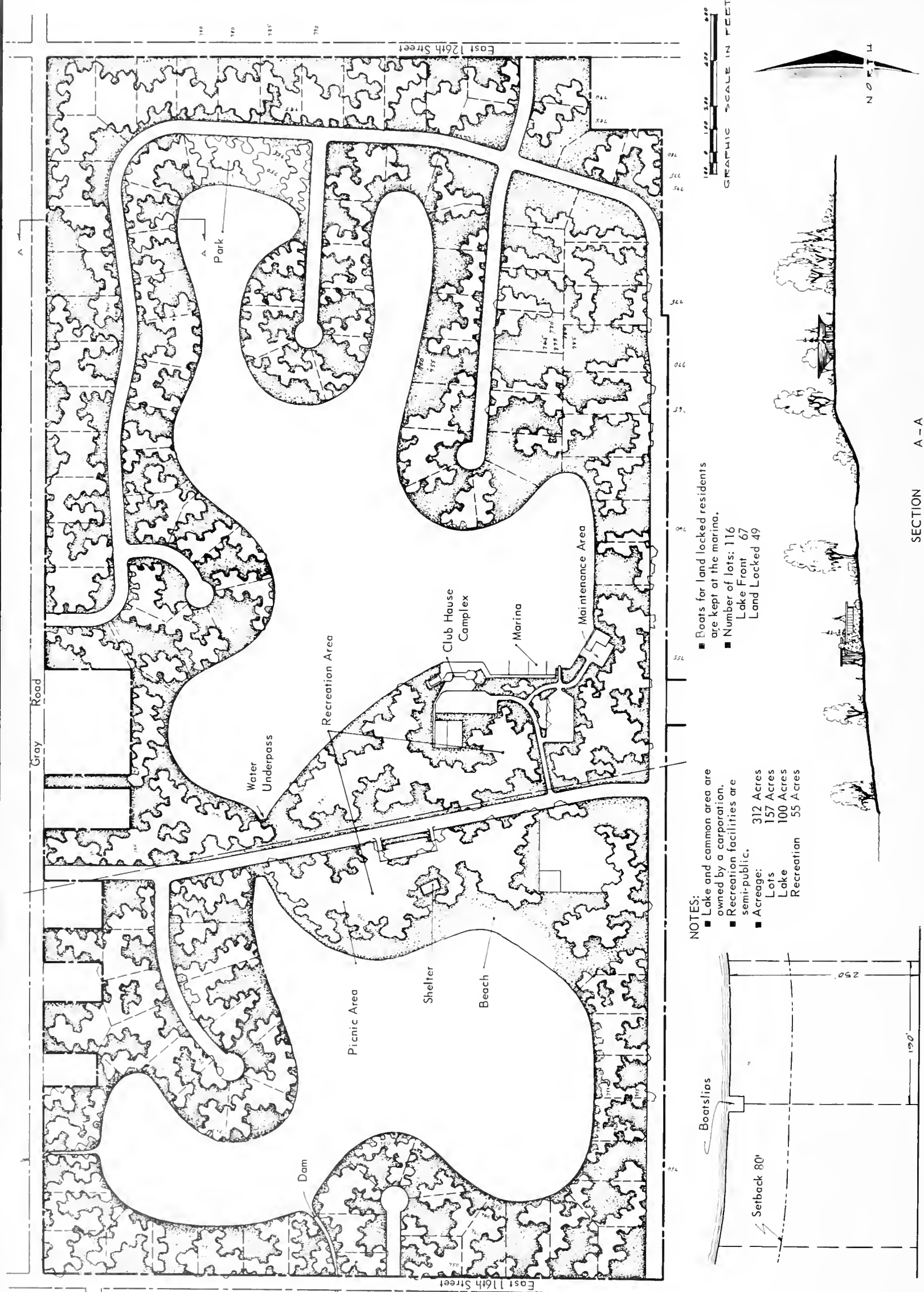
SECTION D - D

Scale 1" = 100'

SANSABAR  
ESTATES

# DEPOSIT ANALYSIS

Fig. 52



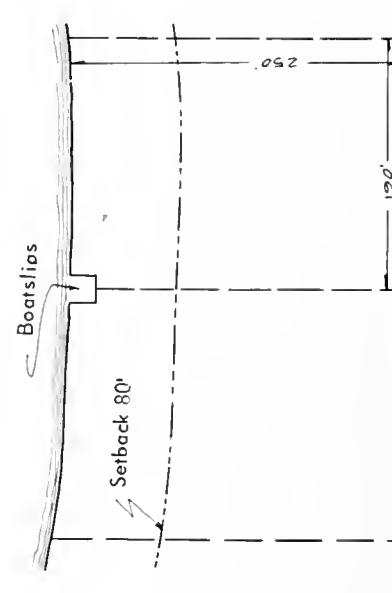
**NOTES:**

- Lake and common area are owned by a corporation.
- Recreation facilities are semi-public.
- Acreage:
 

Lots	312 Acres
Lake	157 Acres
Recreation	100 Acres
	55 Acres

- Boats for land locked residents are kept at the marina.

- Number of lots: 116
- Lake Front 67
- Land Locked 49



Scale 1" = 60'

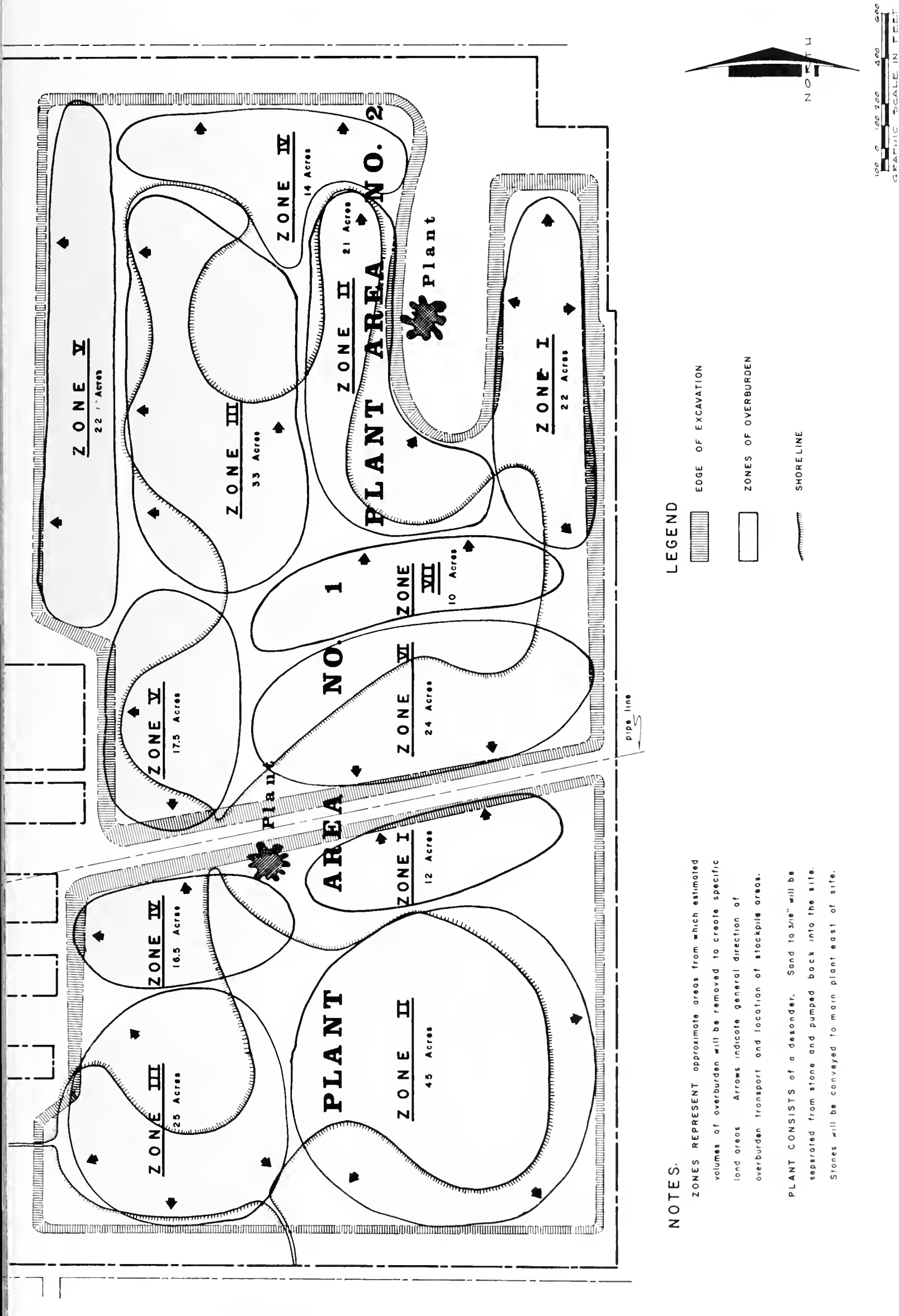


**Fig. 53**

# DEVELOPMENT PLAN

SANSABAR  
ESTATES

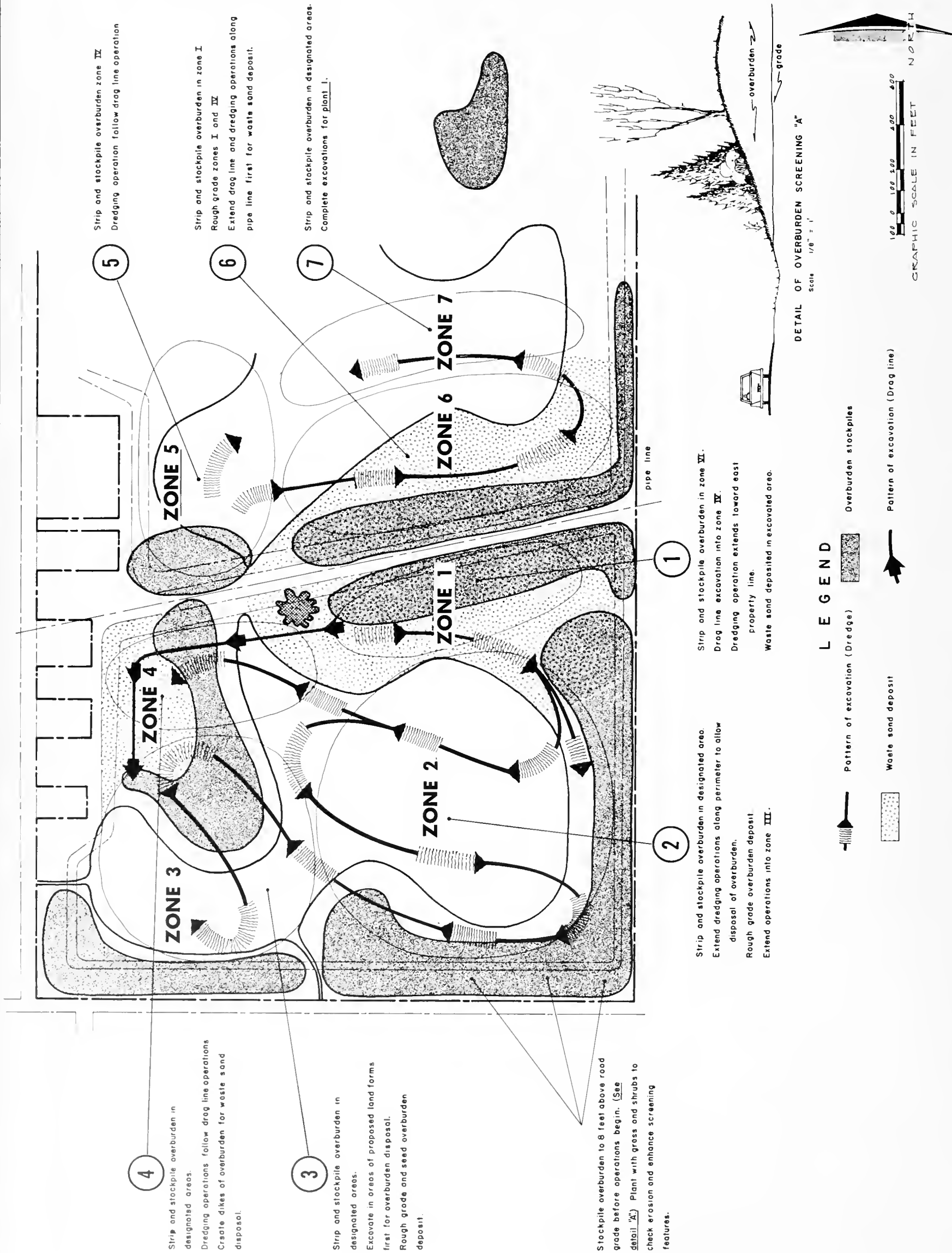


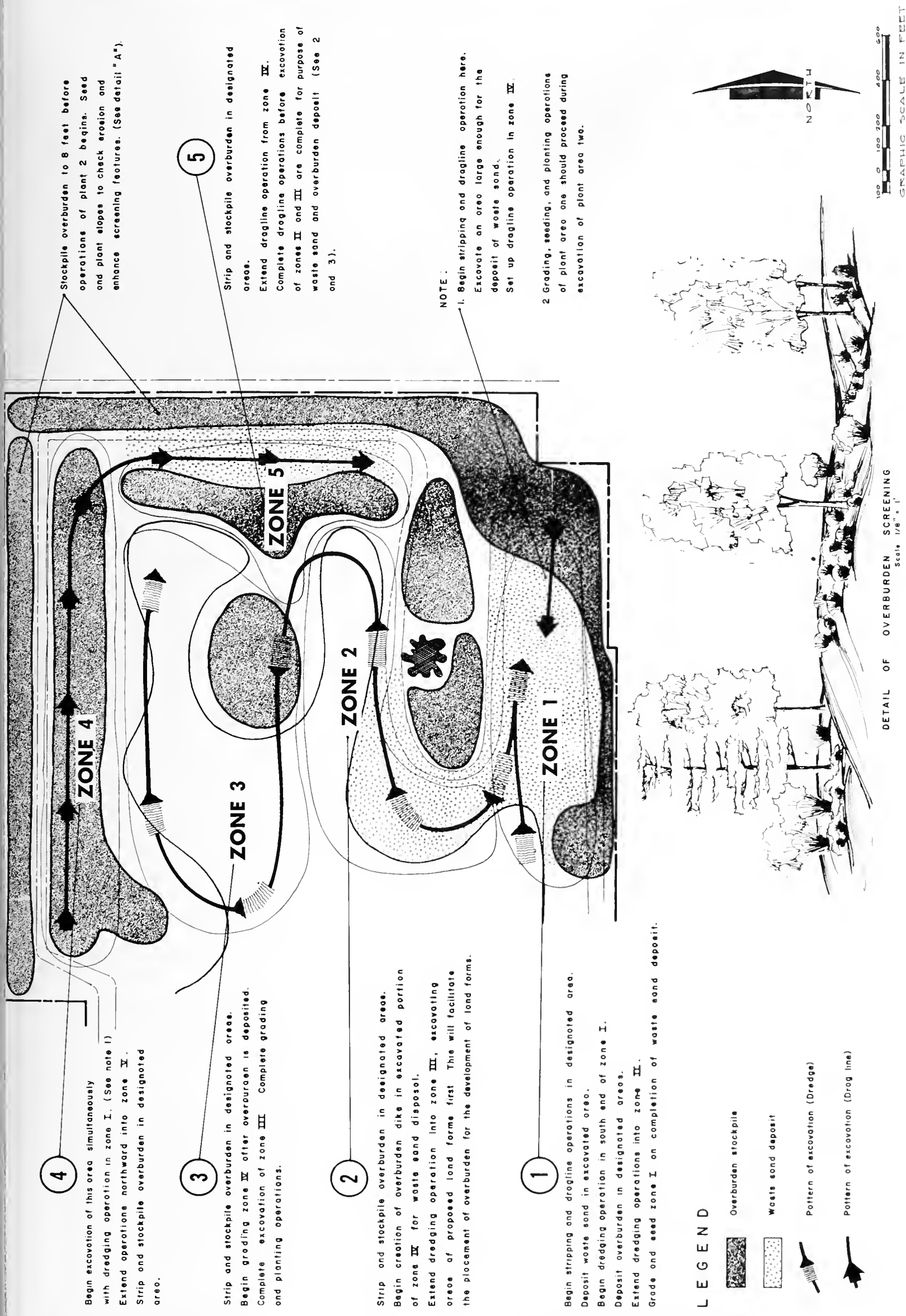


SANSABAR  
ESTATES

# OPERATION ANALYSIS

Fig. 54





**Fig. 56**

**SANSABAR ESTATES**

# Conclusions

Rehabilitation in the sand and gravel industry has been a relatively recent effort. To date, most land improvement programs have been a fix-up of derelict remains. There has been little coordination between the excavation and rehabilitation operations. Although many noteworthy land uses have been created, in a majority of cases the potential of the sites was not fully realized, due to indiscriminate placement of waste material and creation of severe earth work obstacles. However, in the face of expanding populations and more intensive land use, the physical improvement of excavated areas is becoming a more significant function of the sand and gravel industry. The role of the industry is evolving into a two-fold operation: production of sand and gravel, and creation of usable land areas in a drastically altered landscape. Unique land development opportunities are available to the sand and gravel producer. In addition, on the basis of current trends in land use requirements, it is likely that demonstrated responsible land development programs will determine the availability of sites for future development.

The objectives of this research program are to determine planning procedures that will facilitate optimum development of the excavated areas and that will assist in reducing the normal visual and audible operational conflicts. This first report has been concerned with identifying (in relation to planning) the most significant factors of the sand and gravel industry, to explore opportunities for site development, and to present preliminary guide lines for integrating the land development efforts with the excavation process.

It is the premise of this research program that the most functional method of developing depleted sand and gravel sites is by integrating the development effort with the excavation process. In order to achieve this objective, a thorough understanding of the conditions and elements that influence planning and excavation efforts must be attained.

These elements and conditions can be divided into three groups of considerations.

1. Deposit
2. Equipment
3. Location

The characteristics of each group and their interrelationship are the basis for planning and development decisions.

The deposit is the basis for any site development program. Its contents, structure, and boundaries influence the type and character of the proposed landscape. They also affect decisions of equipment selection, excavation patterns, and the type of sand and gravel products to be processed. Currently, information about the deposits is inadequate for accurate and detailed long range planning. Test borings, geological information and other sources of information provide a basis for only educated estimates. Sand and gravel producers must be aware that optimum planning and design decisions are based on detailed information about the above-mentioned groups. Logically, the plan can only be as accurate in detail as the available information.

Deposit factors of most significance are:

1. Depth
2. Presence of unmineable material
3. Composition of sand and gravel
4. Ground water elevation

While the deposit contains the land forming material, the tools required to create desired land forms often consist of the

various pieces of operational equipment. When this equipment is not readily available, land development efforts are hindered.

Each procedure in the sand and gravel operation requires the type of equipment that is best suited to accomplish that particular task, under the set of conditions that exist in and around the deposit. For planning purposes this equipment can be grouped into three categories:

1. Excavating
2. Transporting
3. Processing

Manipulation and location of this equipment is the key to land development. It must be accomplished within the framework of normal operating patterns without significantly affecting the efficiency of sand and gravel production.

Several important equipment characteristics are:

1. Capacity
2. Maneuverability
3. Costs

Although the location of a sand and gravel pit is not the sole factor in selecting a land use and determining a land development program, it is a major influence. If land values and land use demands are low, the detail and amount of land development activity will necessarily be limited, unless the site will contain unique features such as large water areas. It would be folly to propose extensive grading and land development plans for remote rural sites unless unique land use demands exist. Thus in these remote areas, land development improvement objectives should be the reduction and elimination of unsightly remains by means of grading and seeding.

Important location factors are:

1. Views
2. Zoning
3. Surrounding land development
4. Land values
5. Land use demands

Development of the optimum land use and reduction of normal objectionable operating conditions can best be achieved by determining the land uses, land patterns, and methods of operations before excavation of a sand and gravel site begins. Not only will a responsible predetermined land use program improve the image of the sand and gravel operator but it is likely that a real economic gain can be realized by fully utilizing the potential of the altered landscape.

## Future Research

Maximum benefit can be gained by the industry through additional study of general factors before specialized studies or pilot projects are undertaken. The factors of operational potentials, ultimate use potentials, and site planning potentials have been identified as essential considerations for successful planning of sand and gravel sites.

The objectives of continuing research projects will be to identify and analyze operational factors of typical sites, equipment, and procedures; to identify land use potentials of typical sites and to determine requirements for various types of land uses; and to identify typical public relations problems of the industry and demonstrate how the site planning techniques can be effectively utilized to alleviate objectionable site conditions of abandoned pits.



# Glossary

**Dry Operations** — An excavation process that occurs above the water table and does not create water areas.

**Overburden** — The combination of topsoil and subsoil that covers the sand and gravel deposit.

**Planned Development** — A process of arranging the possibilities that evolve from the site, the operations, and the environment into patterns that will eliminate the creation of unusable land areas, and reduce the inherent operational features.

**Reclamation** — A process of reducing, to a desired state, waste and unusable areas resulting from the excavation of sand and gravel.

**Rehabilitate** — To rebuild; to renovate the depleted sand and gravel site to good repute.

**Restoration** — An act of repairing or reconstructing unproductive, useless excavated areas to serviceable lands.

**Surge Pile** — A storage pile, especially in reference to a pile of excavated sand and gravel awaiting further processing.

**Unmineable Material** — Non-sand and gravel materials such as clay, muck, rocks, and topsoil that are unfit for processing and for construction purposes.

**Waste Sand** — Sand that is in excess of market demands. It is separated from the marketable material and deposited in or near the sand and gravel pit.

**Wet Operations** — An excavation process that occurs below the water table leaving water areas behind.

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# Acknowledgments

Like many reports of this nature, it is the culmination of information and ideas from many sources, that make its completion possible. The assistance received from the members of the National Sand and Gravel Association is sincerely appreciated. They have been extremely cooperative and helpful. Special credit is due to the following members for the many hours they devoted to this study and for the wealth of information they contributed: Mr. Roy E. Weaver, Lincoln Sand and Gravel Company, Lincoln, Illinois; Mr. W. I. Thieme, American Aggregates Corporation, Greenville, Ohio; Mr. Cecil Cooley, Cooley Gravel Company, Denver, Colorado; and Mr. Fred Curtis, Lyman-Richey Sand and Gravel Corporation, Omaha, Nebraska.

The author acknowledges the helpful advice, criticism and assistance received from Associate Professor of Landscape Architecture, Thomas C. Hazlett, in organizing the contents of this study.

The author also acknowledges James G. Coke, Director of Community Development, who donated his time and skills as the pilot for the two aerial reconnaissance flights.

The guidance received from the Research Advisory Committee is most appreciated. This committee includes: Professor William G. Carnes, Chairman, Division of Landscape Architecture, University of Illinois; Professor Louis B. Wetmore, Head, Department of Urban Planning and Landscape Architecture; Mr. Roy E. Weaver, Lincoln Sand and Gravel Company; Mr. Kenneth L. Schellie of Schellie Associates, Planning Consultants; Mr. W. I. Thieme, American Aggregates Corporation; and Mr. Vincent P. Ahearn, Jr., Secretary, Committee on Public Relations, National Sand and Gravel Association.



# Notes

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